NOTES ON THE SPAWNING GROUNDS AND EARLY LIFE HISTORY OF THE PACIFIC MACKEREL[1]

By PHIL M. ROEDEL
Bureau of Marine Fisheries
California Division of Fish and Game

INTRODUCTION

For a number of years prior to 1942, the California Bureau of Marine Fisheries made a series of surveys along the California and Lower California coast in order to determine the extent of the spawning grounds of the Pacific mackerel, *Pneumatophorus diego* (Ayres). The work was purely exploratory. Nothing of a quantitative study of egg and larvae production was attempted, and the survey trips themselves were made erratically—usually in conjunction with other research projects—as vessels were available. In 1936, two papers were published (Fry 1936 a, b), the first describing the eggs and early larval stages and the second delineating the spawning grounds as they were then known. From 1936 through 1941, a considerable amount of additional data were obtained both as to spawning grounds and early life history. Because of the extensive egg and larval studies projected for Pacific coast fishes, it seems desirable to present this material, together with a summary of Fry's findings, as an aid to other workers.

SPAWNING GROUNDS

Surveys Prior to 1936

Fry (1936b) reported finding mackerel eggs in four areas: Southern California, Cape Colnett, southern Sebastian Viscaino Bay, and near Pequeña Bay. He found larvae but no eggs at Cape San Lucas and neither eggs nor larvae from Point Conception north to Monterey Bay. Eggs were found most abundantly in water less than 40 fathoms deep with surface temperatures between 62 degrees and 69 degrees F. None were collected beyond the 100 fathom line or in water colder than 57 degrees or warmer than 72 degrees. He notes that surface water temperatures north of Pt. Conception are usually below the 57 minimum.

Surveys Made 1936-1941

These surveys revealed that mackerel spawn along the entire coast from Southern California south to Cape San Lucas and into the Gulf of California at least as far as Espiritu Santo Island (Fig. 31). Though no eggs were collected in the gulf north of Espiritu Santo, larvae were found at several stations between the Island and Concepcion Bay (the northern limit of our explorations) and ripe adults were caught at Mangles Anchorage, about 115 miles above Espiritu Santo and 50 miles south of Concepcion Bay.

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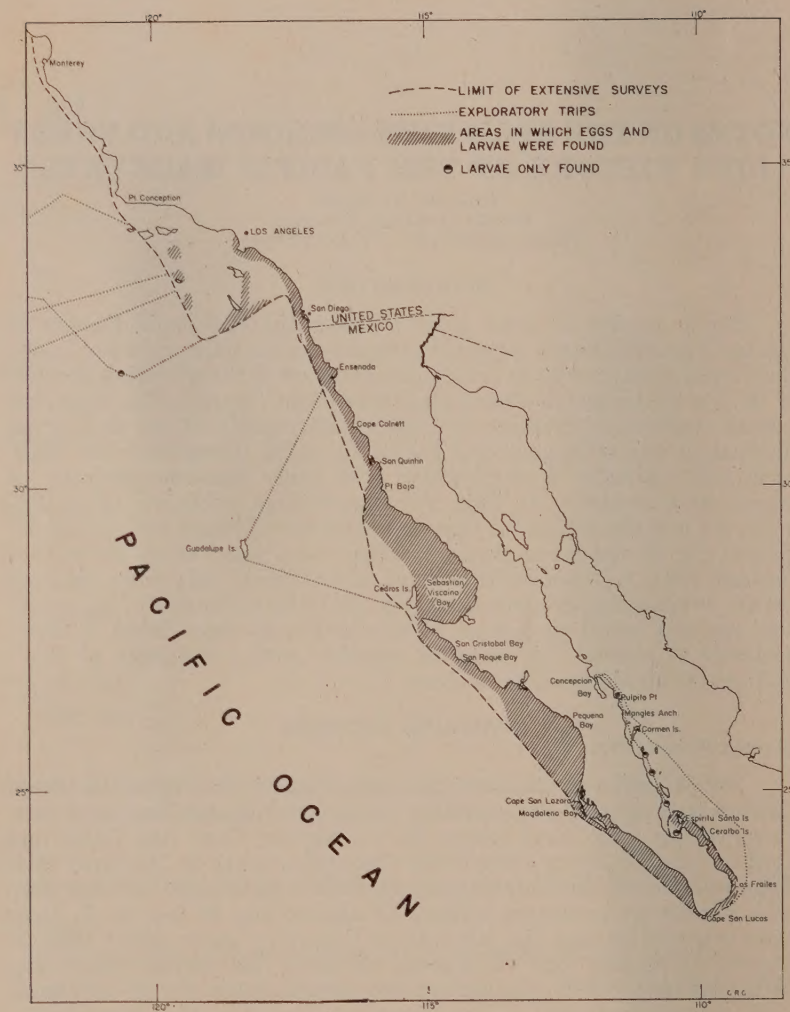

FIGURE 31. Known extent of the Pacific mackerel spawning grounds

Contrary to earlier findings, eggs and larvae were by no means uncommon in depths of up to several hundred fathoms, although they were usually found in water less than 100 fathoms deep. Eggs were never found and larvae found but once beyond the 1,000-fathom line. It is quite possible that they drifted to this position from shallower water. It must be noted that relatively few hauls were made outside the 100-fathom line except off Southern California. The data do indicate that spawning usually occurs fairly close to shore, though it does not appear to be as concentrated in shallow water as first appeared. Surface water temperatures at stations where eggs were found ranged from 59 degrees to 75 degrees F.

The most extensive surveys of Southern California waters were conducted from March through August, 1936. Other cruises were made in May, 1938, and in June and July, 1939. In addition, hauls were made along the mainland from Los Angeles harbor to San Diego on most of the Mexican trips discussed below. Eggs and larvae were found only in the months of May and June. (Fry reports the local spawning season as starting in late April and ending in August or perhaps September). The work in this region included two offshore cruises. The first, made in June 1939, extended some 180 miles beyond San Miguel Island, thence southeasterly to a point about 200 miles west of Ensenada, where three larvae were found in very deep water as noted above, and then to San Clemente Island. The second, made the following month, extended to Erben Bank (Lat. 32°53′N, Lon. 132°35′W), about 700 miles out of Los Angeles harbor. Neither eggs nor larvae were found. A single trip was made into Central California, this in August 1936. Inshore waters were explored as far north as Monterey Bay with negative results.

Nine cruises were conducted in Mexican waters from 1936 through 1941 as follows:

1. Late February-mid-March, 1936: To vicinity of Ceralbo Island, Gulf of California. Eggs and larvae found from Sebastian Viscaino Bay to Cape San Lucas, and larvae in the gulf north of Los Frailes.

2. Mid-June-mid-July, 1936: To vicinity of Ceralbo Island, Gulf of California. Eggs found in the southwest portion of Sebastian Viscaino Bay and off the center of Pequeña Bay at the 100-fathom line.

3. April, 1937: To the south shore of Sebastian Viscaino Bay. Eggs found between San Quintin and Baja Pt.

4. June, 1937: To Ensenada, offshore to Guadalupe Island, thence to the south shore of Sebastian Viscaino Bay, returning to Los Angeles harbor along the coast. Eggs and larvae found off Southern California and near Ensenada. This was the only cruise extending an appreciable distance offshore in Mexican waters.

5. Mid-March-mid-April, 1938: To Magdalena Bay. Eggs in Sebastian Viscaino Bay and north of Cape San Lazaro; larvae off San Cristobal Bay.

6. October, 1938: To Magdalena Bay. No eggs or larvae.

7. Late January-February, 1940: To Concepcion Bay, Gulf of California. Eggs and larvae found from north of Cape Colnett to Espiritu Santo Island; larvae to Pulpito Pt.; ripe adults at Mangles Anchorage. A station line was run offshore from Carmen Island to a point about 35 miles east of Ceralbo Island and thence to a point some 15 miles off Los Frailes. Results were negative, though both eggs and larvae had been found close to shore a few days earlier.

8. February, 1941: To Espiritu Santo Island, Gulf of California. Eggs and larvae found from near Ensenada to Espiritu Santo Island. Young fish, 36 to 54 mm. body length, were collected at Ceralbo and Espiritu Santo Islands, demonstrating that spawning begins, at least in the gulf, at an appreciably earlier date. Their age is not known, but it seems improbable that they were less than two or three months.

9. October, 1941: To Magdalena Bay. No eggs or larvae found.

The length of the spawning season in Lower California cannot be determined from these data. There is some indication that the season in the gulf is earlier than that along the Pacific Coast. It seems safe to say

that it begins no later than December in the gulf, and it apparently had ended there by June the year a trip was made in that month. North of Magdalena Bay spawning was continuing in June and July. While eggs were found in late January and February from the vicinity of Ensenada south, young fish, evidence of an appreciably earlier start to the season, were not captured.

DEVELOPMENT

Eggs and Larvae

Both the development of mackerel eggs and the early larval stages were described and figured by Fry (1936a). According to Fry, newly hatched larvae are about 3 mm. long. Melanophores are distributed irregularly on the oil globule, are found along the sides of the body, usually two on each myomere, and are scattered anteriorally. Yellow chromatophores form a yellow band around the tail, and occur at the posterior rim of the eyes and around the oil globule. At eight hours the melanophores begin to disappear and at 18 or 20 hours, black pigment may be almost lacking. By 30 hours, to quote Fry, "* * * a row of black spots has formed along the ventral side of the tail on each side of the fin fold and there is black pigment along the top of the body cavity. This pattern is retained until the larva is at least ten days old and probably longer. The yellow tail band dwindles in size; by 2½ days it is a small patch, and by four days or less it has entirely disappeared."

Sizes up to 11 mm. (preserved measurements) are represented in subsequent collections and typical examples are shown in Figures 32 to 36. In the 4 mm. specimen pigmentation is much as described by Fry above. At 5 mm., pigmentation on the head and belly is more intense, but the melanophores on the posterio-ventral surface have disappeared. The 7 mm. specimen shows increased pigmentation anteriorally and a row of melanophores along the back. The pelvic fins can be seen. At 9 mm., pigmentation is somewhat less on the belly but is heavier elsewhere. The little fish at 11 mm. has still more melanophores on the head, and heavy rows of black spots along the back and along the bases of the anal and caudal fins.

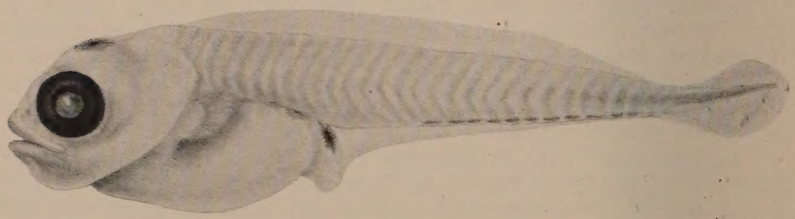

FIGURE 32. Pacific mackerel, 4 mm. *Drawing by Gerhard Bakker, Jr.*

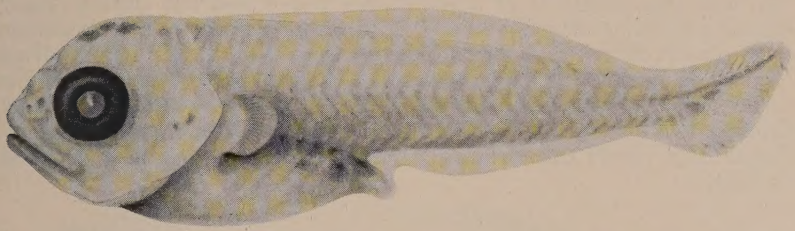

FIGURE 33. Pacific mackerel, 5 mm. *Drawing by Gerhard Bakker, Jr.*

FIGURE 34. Pacific mackerel, 7 mm. *Drawing by Gerhard Bakker, Jr.*

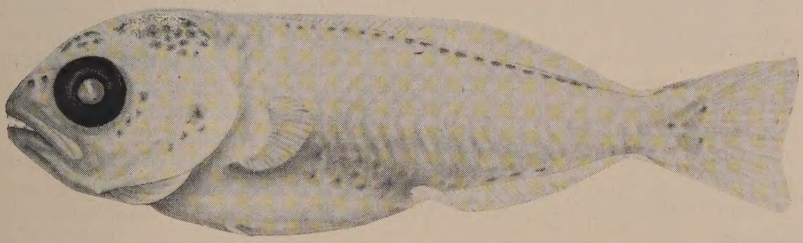

FIGURE 35. Pacific mackerel, 9 mm. *Drawing by Gerhard Bakker, Jr.*

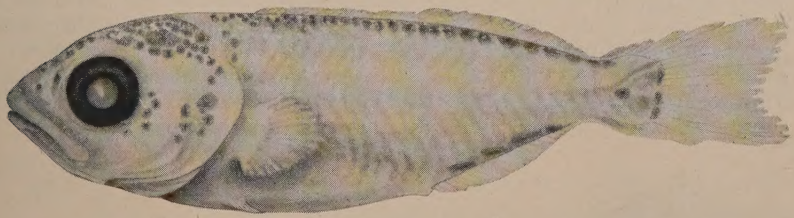

FIGURE 36. Pacific mackerel, 11 mm. *Drawing by Gerhard Bakker, Jr.*

Young Fish

Young fish over 11 mm. and less than 80 mm. are known only from a group of about 15 individuals ranging from 36 to 54 mm. body length. The 45 mm. specimen illustrated (Fig. 37) is typical of this group and is unmistakably a mackerel. When these fish were first caught, the beginning of the characteristic zebra stripes of the adult could be seen.

The markings consisted of a few rather heavy and but slightly wavy bars. No attempt was made to add them to the drawing which was made from preserved material. The specimens were taken in dip nets under a light while anchored in calm bays close to shore. Locality records include Isla Partida Harbor, Espiritu Santo Island and the southwest side of Ceralbo Island, both in the Gulf of California (Feb. 1941), and San Roque Bay, Lower California (Oct. 1941 and including the individual figured).

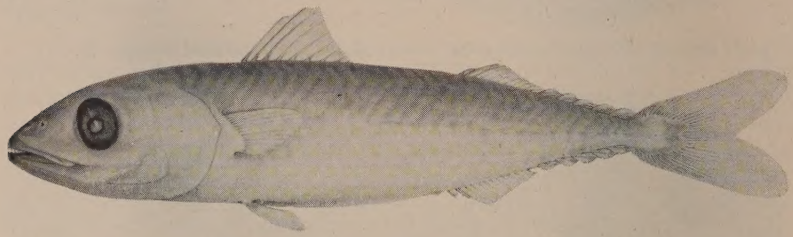

FIGURE 37. Pacific mackerel, 45 mm. *Drawing by Gerhard Bakker, Jr.*

Progression of Ossification in Larvae

In the course of a racial study of the mackerel, it was found that the initial position of several structures on the vertebral column varied in some degree with geographical locality. It then became desirable to know at what developmental stage the position of these structures became fixed. By following in general the KOH-alizarin method of Hollister (1934) we were able to obtain a highly satisfactory series of cleared and stained larvae up to 11 mm. in length. Examination of this material showed that the first haemal arch was closed on vertebra 11 in all individuals over 8.1 mm. while the first haemal spine appeared on vertebra 15 in those over 7.5 mm. These are the usual positions in over 90 percent of adult mackerel. The centra showed little evidence of ossification at this size.

Typical 5, 8, and 11 mm. specimens are shown in Figures 38 to 40. The drawings indicate clearly the progression of ossification. At 5 mm., the jaw bones, vomer, parasphenoid, basioccipital and all four opercular bones can be distinguished as can the ceratohyal and four of the branchiostegals. The hyomandibular appears as two widely separated pieces. The pectoral girdle and a few caudal rays are evident. The vertebral column shows no trace of ossification and the cranium but little.

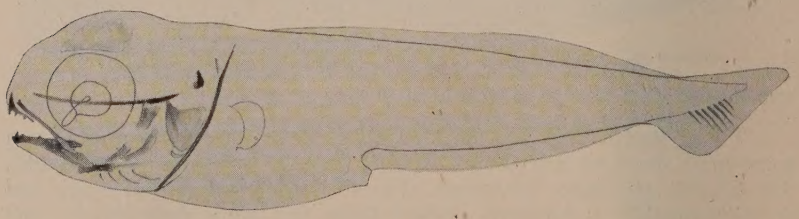

FIGURE 38. Pacific mackerel, 5 mm., cleared and stained. *Drawing by Gerhard Bakker, Jr.*

At 8 mm., the quadrate, pterygoid, and metapterygoid are forming and all the branchiostegals are present. The urohyal is distinct, as are the branchial arches. The latter are not shown in the drawing for sake of clarity. From the dorsal aspect, a tiny supraoccipital crest can be seen. It lies below the level of the adjoining cranial bones in the lateral view. As stated above, the positions of the first haemal arch and spine are fixed at this size even though ossification of the vertebral column is

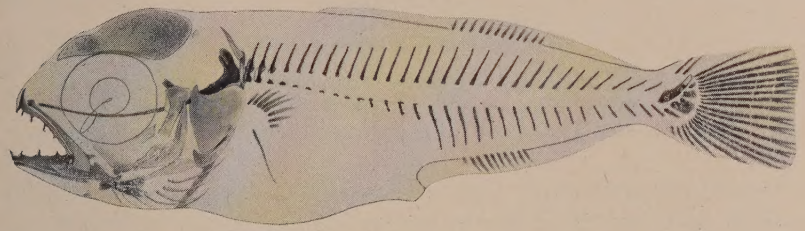

FIGURE 39. Pacific mackerel, 8 mm., cleared and stained. *Drawing by Gerhard Bakker, Jr.*

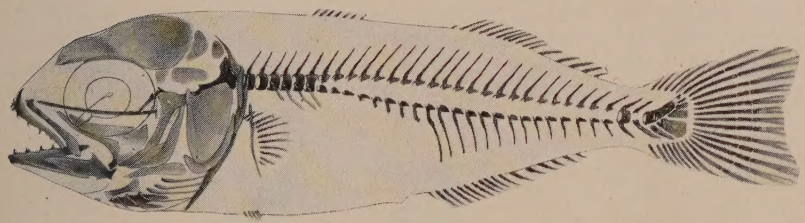

FIGURE 40. Pacific mackerel, 11 mm., cleared and stained. *Drawing by Gerhard Bakker, Jr.*

confined to the first two and the last vertebrae. The first dorsal and pelvic fins remain undifferentiated, but the others are well marked.

The 11 mm. specimen shows considerable development over the 8 mm. stage. The two portions of the hyomandibular are joined and the palatines, mesoptergoid and basisphenoid are visible. Ossification of the vertebral column is progressing rapidly. The first six vertebrae are formed and ribs are taking shape. All fins are clearly defined and the five dorsal and anal finlets can be distinguished from the adjoining rays.

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OBSERVATIONS AND NOTES ON SOME CALIFORNIA MARINE FISHES[1]

By JOHN E. FITCH
Bureau of Marine Fisheries
California Division of Fish and Game

The appearances of the several species of fish listed below are unusual enough to warrant a published record. These specimens have come to the attention of the California State Fisheries Laboratory since the last series reported by Fitch (1949).

Polydactylus approximans (Lay and Bennett) Pacific threadfin (Fig. 41)

A specimen approximately one foot in total length was taken by Mr. William O. Woodworth of Coarsegold, California, during the summer of 1941. He was fishing in the surf at Sunset Beach just south of Long Beach, California, and was using long-handed ghost shrimp (*Calianassa longimana* Stimpson) for bait. His catch was identified from excellent photographs which were sent to the laboratory in January, 1949. According to Mr. Woodworth the flesh of the threadfin proved to be quite tasty when it was eaten by his family.

FIGURE 41. Pacific threadfin. *Polydactylus approximans. Photo by Hawthorne Studios, Los Angeles*

Barnhart (1936) gives the range of this species as the tropical east Pacific rarely to San Diego and Santa Catalina Island. Jordan and Starks (1907) state that this species is common about Mazatlan, and "has been once taken at Santa Catalina and once at San Diego." Follett (1948) in a review of this species gives the range from Callao, Peru to Santa Catalina Island, California. He also gives a detailed description of a

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specimen taken in Monterey Bay, California (a northerly extension of the recorded range) and lists seven other specimens taken in California waters and previously unrecorded.

Seven of the eight specimens he lists were taken during a 12-month period between August, 1940, and August, 1941. For the eighth he gives no date of capture. The specimen taken by Mr. Woodworth also falls into the 12-month period mentioned above and all except one were taken in the fairly limited area between San Clemente and San Pedro, California.

The number of specimens taken in California during this relatively short period opens to speculation the possibility that they were brought as far north as San Pedro during the summer of 1940 in the bait wells of a tuna clipper and dumped into our waters when the bait tanks were drained. For fish as small as these were, the above theory is entirely within reason; however in the absence of proof their occurrence this far north could be attributed as logically to natural migrations.

O. taylori (Girard) (Fig. 42) was also taken in considerable numbers in the same vicinity. The two species closely resemble each other and there is a certain amount of overlap in their ranges. *O. scrippsi* has four to six gill rakers in the lower limb of the outer gill arch while *O. taylori* has seven to nine. *O. scrippsi* is also deeper bodied and has a larger head.

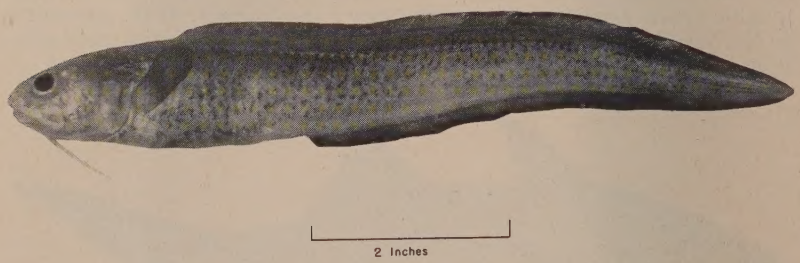

FIGURE 42. Spotted cusk-eel. *Otophidium taylori. Photo by Al Johns for Vernon M. Haden, San Pedro*

Spirinchus starksi (Fish) (Fig. 43) Night smelt

This species is a member of the true smelt family (Osmeridae) and in Northern California is of considerable commercial importance being marketed with several other kinds of small fish as whitebait. Its range according to Roedel (1948) extends from Monterey Bay, California,

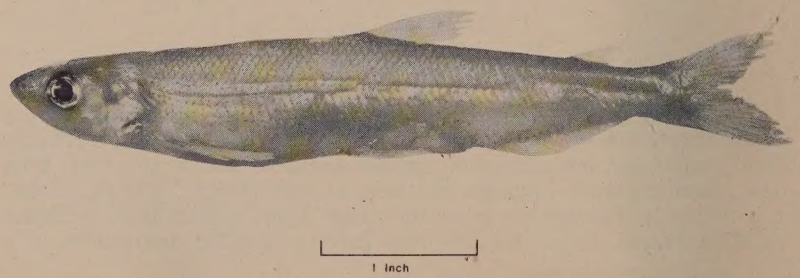

FIGURE 43. Night smelt. *Spirinchus starksi. Photo by Al Johns for Vernon M. Haden, San Pedro*

north into Washington. This fish is the northern counterpart of the grunion, *Leuresthes tenuis* (Ayres), which is found along the coast of Southern California. During its spawning season *Spirinchus starksi* runs into the extremely shallow water along the coast and though it does not actually beach itself as does the grunion it can be found in considerable numbers in the backwash of the waves. As with the grunion it also spawns at night.

During the operations of the oil exploration crews between Point Arguello and Morro Bay, California, in November and December, 1948, a number of these osmerids were killed and floated to the surface and were recovered by Wedgewood. Not only do these records extend the southerly range for this species some 100 miles beyond that given by Roedel, but also the fact that they were found in fair numbers and in water ranging in depth to 200 feet is of considerable importance. Previously they had been considered a shallow water form not usually occurring much beyond the breaker line in the surf.

Lepidogobius lepidus (Girard) Bay goby

An adult bay goby was picked up by Mr. Robert Wedgewood of the staff of the Bureau of Marine Fisheries some two miles off Pismo Beach, California in November, 1948. It was killed by a charge of explosives detonated at the surface of the water by a geophysical survey crew conducting a search for underwater oil deposits. Mr. Wedgewood recovered the specimen during a routine post-detonation inspection of the area when it was observed floating dead upon the surface along with a number of other species of fish killed in the same blast.

Lepidogobius is one of the very common shallow water gobies in the vicinity of San Francisco Bay and is found from there to Vancouver Island, British Columbia. South of San Francisco Bay it is a rare visitor and according to Barnhart (1936) has been recorded as far south as Lower California. It is of interest that the present specimen was killed in water between 100 and 200 feet deep and its collection adds to the localities where this species has been recorded south of San Francisco Bay.

Otophidium scrippsi Hubbs California cusk-eel

Three of these cusk-eels were also collected by Wedgewood off Point Arguello, California, during November, 1948, and several more were picked up in the same vicinity during December, 1948. All were killed by explosives and floated to the surface. Previously this species was known from Cedros Island, Lower California, to San Pedro. The present specimens extend the range to the north some 150 miles.

Lophotus sp. Crestfish

On August 20, 1948, a very rare crestfish or oarfish of the genus *Lophotus* was taken on hook and line near Santa Catalina Island (Fitch, 1949). This was but the second Pacific Coast record for this fish, the first specimen having been taken in 1919 near Long Beach, California. On January 29, 1949, just five months after this second crestfish was taken, another was landed, this by Mr. Norman Levin of Hollywood. Mr. Levin hooked his fish near Bel-Air while fishing some 85 yards offshore. He was using mussel (*Mytilus*) for bait and fishing on the bottom in what he estimated to be 80 feet of water. The specimen was almost exactly the same length as the one landed in August, 1948, and the external appearance identical. It weighed but four pounds for all its 39 inches of length

and according to Mr. Levin, put up "a little fight for about a minute." It has been preserved at Scripps Institution of Oceanography, La Jolla, California, where both it and the August, 1948, specimen will be studied and reported upon in considerable detail at some future date.

Neoclinus satiricus Girard Sarcastic fringehead

During January, 1949, Mr. Charles C. Isbell a commercial diver from Long Beach, California, brought into the laboratory the jaws of a fish he had taken off Santa Cruz Island. The extremely long maxillary and the bright yellow edge of an otherwise blackish maxillary membrane were the two characteristics which identified it as *Neoclinus satiricus*. Mr. Isbell stated that the specimen measured approximately 12 inches in total length, well over the nine-inch maximum given by Barnhart (1936).

The collection of the specimen was slightly unorthodox in that Mr. Isbell, working in 110 feet of water, had noticed a number of these fish living in holes along the bottom with their heads sticking up flush with the floor of the ocean. The jaws were partially open exposing numerous sharp teeth. Mr. Isbell struck one of the largest heads with a diving hammer, ran the stunned fish through with his belt knife and removed it from its burrow. From the size of the head he expected a specimen of considerable length and was extremely surprised to note the comparatively small body.

This species apparently lives in burrows in the bottom which may be one reason that specimens are not more often taken in drag nets and by other conventional methods of collecting. According to the diver's observations they are not too uncommon in a number of localities at moderate depths.

Rhinotriakis henlei Gill Brown smoothhound.

On November 3, 1941, a specimen of this shark was caught on hook and line at San Carlos Anchorage, Lower California (Lat. 29° 37′ N, Lon. 115° 28′ W.). The range of the species, limited to the coast of California in published records, is thus extended south some 200 miles below the Mexican boundary. The fish was caught during a cruise of the California Division of Fish and Game research vessel *N. B. Scofield* and was identified by R. S. Crocker and P. M. Roedel. An entry was made in the trip report but was overlooked in compiling previous articles on range extensions.

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THE FOOD OF YOUNG LARGEMOUTH BLACK BASS *(MICROPTERUS SALMOIDES)* IN CLEAR LAKE, CALIFORNIA[1]

By Garth I. Murphy
Bureau of Fish Conservation
California Division of Fish and Game

INTRODUCTION

This study was undertaken to ascertain the mid-summer feeding habits of black bass of the year in Clear Lake, Lake County. A description of the feeding habits with increasing size of the fish was sought. In addition it was desired to learn the forage species most utilized by the bass, and whether or not cannibalism within the year class existed to an appreciable extent.

MATERIAL

The collections used in this study were seigned from Clear Lake during the period August 10-12, 1948, using a 40-foot by 6-foot, four to the inch mesh seine. All collecting was done along the five-mile stretch of shoreline between Lakeport and Rodman Slough, on the northwestern end of the lake. Two hundred and sixty-four whole specimens were preserved in formalin for later examination.

METHODS

Stomachs were removed from the preserved specimens, the contents sorted, and volumetric determinations of the various classes of food organisms made by water displacement in a graduated centrifuge tube.

All data from each specimen, including location of capture, length of fish, and the classes of food organisms in the stomach, were entered on "Speed Sort" cards. These have a series of holes in the margin. Data are entered on the cards by cutting out a wedge to the margin from the appropriate hole. A separate card is used for each specimen. Sorting is accomplished by inserting a needle in the appropriate hole and lifting the stack of cards vertically. All cards cut at that hole then drop out of the stack. This technique is used to sort the cards for any attribute of the specimens that has been entered. Considerable time is saved by using this system when dealing with multiple data on individual specimens, especially when multiple tabulations of the data are needed. The time required to enter the data on the cards is slight (about one minute per card when five entries are made) and the entries could be readily made by a clerk.

[1] Submitted for publication March, 1949.

GENERAL ECOLOGY OF THE STUDY AREA

The most prominent fish in the study area were largemouth black bass *(Micropterus salmoides)* bluegill *(Lepomis macrochirus)*, sculpins *(Cottus sp.)*, and greaser blackfish *(Orthodon microlepidotus)*. Black bass of the year averaged 29 per seine haul; bluegill, intermediates (in this case, mainly fish of the 1947 hatch), and fry, averaged 77 per haul; blackfish averaged around eight per haul (exact counts were not made); and sculpins averaged about eight per haul (exact counts were not made). There were large numbers of bluegill too small to be taken in the seine. Sculpins could not be expected to appear in their true relative abundance since they live on the bottom and tend to escape capture by seine. Blackfish were actually more abundant in the lake than the figures indicate because the center of distribution of young of the year was farther offshore than the area in which the seine hauls were made, i.e., over 40 feet.

Insect foods, particularly larval midges and corixids (all instars), and zooplankton were abundant, judging from gross observations. In general, the food situation at the time was such that an abundance of the three types of food (fish, insects, and plankton) existed and presumably young bass were able to exercise choice in selecting their diet.

FOOD OF THE BASS

Table 1 gives the length frequencies of the specimens used. It does not reflect the size composition of the bass population because selection was exercised in order to obtain adequate representation from the various size classes. It does, however, represent the range of sizes of the bass of the year at the time the collections were made.

TABLE 1

Length Frequencies in Inches of Largemouth Bass Used in Food Study

Length class[1]	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1
No. specimens	8	22	12	26	46	43	21	13	11	13
Length class[1]	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7		
No. specimens	9	7	11	4	4	6	2	1		

[1] The figures given are the lower limits of the respective classes. Fork length was used.

Table 2 indicates the various types of food consumed by the bass, and gives an adequate picture of the relative importance of each food class in the diet.

TABLE 2

Food Classes Consumed by Largemouth Bass, Their Frequency of Occurrence and Total Volume

Class	*Frequency*	*Volume*
Fishes		
Blackfish	28	37.8cc
Bluegill	6	3.1cc
Sculpin	15	8.8cc
Carp *(Cyprinus carpio)*	1	1.0cc
Unidentified	24	7.2cc
Crustacea		
Water Fleas (Cladocera)	53	1.32cc
Scuds (Gammarids)	35	0.44cc
Insecta		
Water Boatmen (Corixidae)	142	6.04cc
Damsel Flies (Odonata)	32	1.38cc
May Fly (Ephemeridae)	8	0.08cc
Fly Larvae (Diptera)	38	0.40cc
Midge pupae (Chironomidae)	27	1.87cc
Unidentified	6	0.15cc
Miscellaneous Invertebrates	8	0.14cc
Empty	10	

Figure 44 indicates the relative importance of each major class of food to the various size groups of bass. The curves in Figure 1, although based on frequency of occurrence, indicate rather closely the actual importance of each class of food to the fish, in terms of volume of food. Plankton was an important food for fish below two inches in length, though decreasing in importance as the fish approached two inches in length. From 1.8 to 2.8 inches in length, insects were the most important dietary item, and from three inches upward fish were the only item taken in any significant amount. Generally, specimens larger than three inches in length that had taken foods other than fish had fish in their stomachs too, indicating that such items were incidental in their diet.

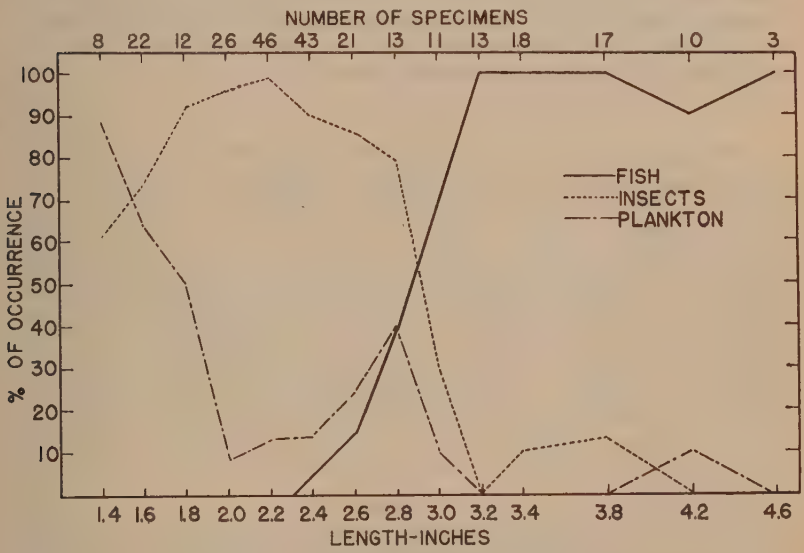

FIGURE 44. Composition of the stomach contents of young largemouth bass. The figures representing size are the lower limits of the classes

This transition in feeding habits is regarded as a natural change brought on by the choice of the individual fish. As pointed out earlier, all types of potential bass food were abundant in the area, making it possible for the bass to select the preferred food as opposed to limitations of supply dictating the selection.

Referring to Table 2, it is of interest to note the relative unimportance of bluegill in the diet. Judging by the composition of the seine haul catches, bluegill were the most important available forage fish. The hatch of the year ranging up to three-fourths inch in length was abundant while young blackfish were scarce. Young blackfish are probably more available than bluegill, since they inhabit the littoral zone, but are not closely associated with cover, while young bluegill tend to remain closely associated with plant cover. In addition, there may be a preference factor. Blackfish are a slender, fine scaled, smooth minnow, as opposed to the deepbodied, prickly bluegill. As an illustration of the consumability of young blackfish, a 2.4-inch partially digested blackfish was found in a 4.1-inch bass. The importance of blackfish as a forage fish as indicated

by the data herein presented is substantiated by spot checks on the stomach contents of young and adult bass in other sections of the lake, indicating that blackfish were the forage fish taken in greatest numbers during the last half of the summer season.

The frequency of sculpins in the bass diet (Table 2) was unexpected. These fish are not readily captured by seine since they adhere to the bottom, making seine haul estimates of their relative abundance unreliable. However, the data in Table 2 indicate that they play an important role in the littoral economy of Clear Lake.

No evidence of interyear class predation was obtained, though in some cases over seventy bass were captured in one seine haul, and the composition of the catch indicated that smaller bass were the most abundant food available to the larger bass. Probably the same factors, availability and desirability, that mitigated against the full utilization of young bluegill, operated in the case of smaller bass.

DISCUSSION

This study indicates that bluegill fry are not an important item of bass food in Clear Lake, though relatively abundant at the time the study was made. This is in opposition to experience in southern farm ponds, where bluegill constitute the chief bass forage. One factor relative to the usefulness of bluegill as forage fish in Clear Lake is the fact that they spawn about 1 to 1½ months later than the bass, due to their higher temperature requirement. Blackfish and other cyprinid forage fish spawn earlier than or about the same time as bass. In the absence of the fry of these fish, the young bass and sculpins must bear the brunt of the predation from older fish until the appearance of the bluegill hatch. Under such circumstances, one would expect a lower survival of bass to the fingerling stage. In 1947 the cyprinid spawning was a virtual failure, and bass of the year at fingerling size were only about one-eighth as abundant as during 1948.

Since blackfish are a lake spawning fish and since preliminary studies indicate that they are plankton feeders, they may be extremely valuable as forage fish in fluctuating reservoirs whose economy is almost solely dependent on plankton, just as the gizzard shad supplies forage in midwestern and southern reservoirs.

Cooper (1936) and Ohio Division of Conservation (1925) show a transition of feeding habits of young bass similar to that herein described, indicating the feeding pattern in Clear Lake is a normal one under environmental conditions favorable to the exercise of feeding choice by the bass. The work of Cooper (1936) was carried out under artificial rearing pond conditions and there are indications that the foods consumed by his specimens were to some extent forced on the fish by environmental limitations.

This study furnishes clues to the food picture that must be provided bass in nature and in rearing ponds if satisfactory production is to be obtained. The most important factor appears to be the provision of a supply of suitable-sized forage fish when the fingerlings reach 2.5 to 3 inches in length.

SUMMARY

1. The stomachs of 264 largemouth black bass of the year, collected from the northwest shore of Clear Lake during the period August 10-12, 1948, were examined.

2. The section of the lake from which the specimens were collected presented the bass with an abundance of the three main classes of food; namely, plankton, insects, and forage fish. It appears in all probability that selection of diet by the bass was a matter of choice and not environmental limitation.

3. Plankton and small insects were the chief foods of bass below 1.8 inches in length; insects the chief food of those between 1.8 and 2.8 inches; and fish almost the exclusive food of specimens over 2.8 inches in length.

4. Greaser blackfish were the most important forage fish taken, and corixids the most important insect food. Preliminary indications are that greaser blackfish may prove to be a desirable forage fish in fluctuating reservoirs.

5. No evidence of interyear class predation in bass of the year was detected.

Literature Cited

Cooper, G. P.

1937. Food habits, rate of growth and cannibalism of young largemouth bass *(Aplites salmoides)* in state-operated rearing ponds in Michigan during 1935. Trans. Am. Fish. Soc., vol. 66, 1936, pp. 242-266.

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1925. The food of young large- and small-mouth black bass in Ohio. Ohio Division of Conservation, Bureau of Scientific Research, Bull. 10, 1925, 2 pp. mimeographed.

AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND CANADA IN 1948-49[1]

By Frances E. Felin [2]
United States Fish and Wildlife Service
Julius B. Phillips and Anita E. Daugherty
California Division of Fish and Game

This is a third report on age and length composition of the sardine *(Sardinops caerulea)* catch off the Pacific Coast of the United States and Canada and covers the 1948-49 season.

Methods of sampling the catch and determination of ages were continued in the same manner as formerly reported (Felin and Phillips, 1948).

In addition to the regular commercial fishing season of 1948-49 the California interseasonal fisheries at Monterey and San Pedro were sampled in 1948. For Monterey this interseason extended from February 16, 1948, to July 31, 1948, i.e., from the close of the regular 1947-48 season to the start of the 1948-49 season. San Pedro interseason fishing was carried on from March 2 to September 30, 1948. However, in Monterey no samples were taken during the "March" and "April" lunar months; and in San Pedro none were taken during "June" and "July."

For interseason fisheries age and length composition, estimated numbers of fish caught, mean lengths and standard error of the means of each year-class are presented in Tables 1 through 4.

For the regular season, Tables 5 through 7 give age and length composition in Oregon. No samples were obtained from the other Pacific Northwest ports in Washington and British Columbia where no sardine landings of any consequence were recorded. Tables 8 through 10 show similarly the same data for California ports together with the Pacific Northwest summary and a summary for the entire coast. Number of fish, mean length, and standard error of the mean of each year-class in the samples for 1948-49 by region of catch are given in Table 11. Calendar dates for lunar months in the 1948 interseason and 1948-49 season are given in Table 12. Table 13 gives age composition of the catch in terms of numbers of fish caught in the Pacific Northwest and in California. As in the 1947-48 season, no samples were taken of the very small landings at San Francisco.

Estimates of age from scales were made by the following biologists: Kenneth H. Mosher and Frances E. Felin of the U. S. Fish and Wildlife Service; J. B. Phillips and Anita E. Daugherty of the California Division

[1] Submitted for publication April, 1948.
[2] Published by permission of the Director, U. S. Fish and Wildlife Service.

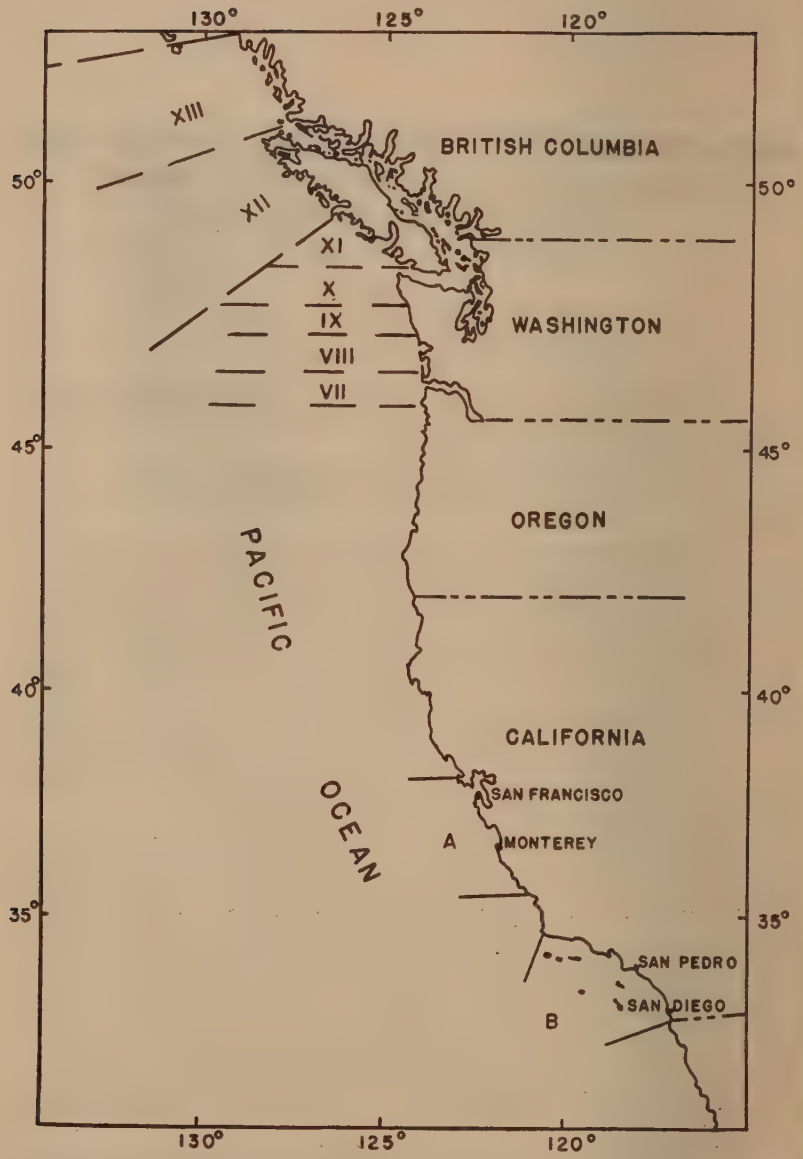

FIGURE 45. Sardine fishing areas. VII-XIII, areas in the Pacific Northwest fishery. (Areas V and VI off Oregon also were fished in 1948 and are of the same magnitude as areas VII and VIII.) A, San Francisco-Monterey fishing grounds. B. Southern California fishing grounds

of Fish and Game. The results of the determinations of age for the 1948-49 season are presented without interpretation.

We wish to thank the other agencies, the Fisheries Research Board of Canada, the Washington State Department of Fisheries, and the Fish Commission of Oregon for their continued cooperation in this program. The help of all those persons of the several agencies who have aided in the collection of scales, mounting of scale samples and in processing the data is gratefully acknowledged.

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1949. Age and length composition of the sardine catch off the Pacific Coast of the United States and Canada in 1947-48. Calif. Fish and Game; vol. 35, pp. 15-40.

TABLE 1

Length Composition of All Year-Classes for Monterey 1948 Interseason

Length mm.	Year-classes												Total		
	1947			1946			1945					1939			
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
124	---	1	1										---	1	1
126															
128	---	1	1										---	1	1
130															
132															
134															
136															
138	1	---	1										1	---	1
140															
142	1	---	1										1	---	1
144	2	1	3										2	1	3
146	1	---	1										1	---	1
148	3	1	4										3	1	4
150	5	2	7										5	2	7
152	3	4	7										3	4	7
154	9	4	13										9	4	13
156	9	5	14										9	5	14
158	11	7	18	---	1	1							11	8	19
160	12	12	24	---	1	1							12	13	25
162	15	15	30										15	15	30
164	12	11	23	2	---	2							14	11	25
166	10	14	24	1	---	1							11	14	25
168	9	9	18	---	2	2							9	11	20
170	16	12	28	1	2	3							17	14	31
172	16	10	26	---	1	1	---	1	1				16	12	28
174	14	10	24	2	---	2							16	10	26
176	11	7	18	1	1	2							12	8	20
178	7	7	14	2	1	3							9	8	17
180	8	7	15	1	1	2							9	8	17
182	1	5	6	4	---	4	---	1	1				5	6	11
184	3	---	3	3	---	3							6	---	6
186	1	1	2	1	1	2							2	2	4
188				1	4	5							1	4	5
190	---	2	2	1	1	2							1	3	4
192				1	---	1							1	---	1
194															
196				---	1	1							---	1	1
198				1	3	4							1	3	4
200															
202				1	---	1	1	---	1				2	---	2
204															
206															
208															
210				1	---	1							1	---	1
212															
214							---	1	1				---	1	1
216															
218							1	1	2				1	1	2
272										---	1	1	---	1	1
Totals	180	148	328	24	20	44	2	4	6	---	1	1	206	173	379

TABLE 2

Length Composition of All Year-Classes for San Pedro 1948 Interseason

Length mm.	Year-classes												Total		
	1947			1946			1945			1944			1943			1942					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
154					1	1														1	1
156																					
158																					
160				1		1													1		1
162	1		1	1		1													2		2
164				1		1													1		1
166				6	6	12													6	6	12
168	1		1	7	3	10													8	3	11
170				12	7	19													12	7	19
172	2		2	15	12	27													17	12	29
174				13	19	32	1	1	2										14	20	34
176				21	23	44	1		1										22	23	45
178				11	23	34													11	23	34
180				6	8	14													6	8	14
182	2		2	2	5	7	1	1	2										5	6	11
184		1	1	3	5	8													3	6	9
186				1	2	3													1	2	3
188	1		1	2	3	5													3	3	6
190	1		1	7	11	18													8	11	19
192		1	1	11	2	13		1	1										11	4	15
194				9	6	15	2		2										11	6	17
196				9	12	21		1	1	1		1							10	13	23
198				4	12	16	2	1	3		1	1							6	14	20
200				4	3	7	3	1	4										7	4	11
202				4	12	16	2	5	7		1	1							6	18	24
204				3	7	10	1	1	2	1		1							5	8	13
206				1	1	2		1	1										1	2	3
208				1	3	4	1	1	2										2	4	6
210							1	2	3		1	1		1	1				1	4	5
212					2	2	1	1	2	2	1	3							3	4	7
214							1		1										1		1
216								1	1	1	1	2		1	1				1	3	4
218							1		1					1	1				1	1	2
220													2		2				2		2
222																	1	1		1	1
224													1		1				1		1
226								1	1											1	1
228								1	1											1	1
238														1	1					1	1
Totals	8	2	10	155	188	344[1]	18	20	38	5	5	10	3	4	7		1	1	189	220	410[1]

[1] Includes one fish, length unknown.

TABLE 3

Age (Year-class) Composition of the Sardine Catch for Monterey and San Pedro 1948 Interseason

(Numbers of Fish Are Given in Thousands, i.e., 000 Omitted)

	Catch		Number of fish by year-class									
	Tons	Number	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938
Monterey												
"February"	30	275		139	79	27	15	10	4		1	
"March"	139	1,287		649	369	125	71	49	18		4	2
"May"	1,259	19,814	15,059	3,566	1,189							
"June"	4,194	65,837	61,419	4,418								
"July"	4,391	61,104	55,464	4,699	471							
"August"	1,444	17,877	11,799	5,363	715						470	
Totals, Monterey	11,457	166,194	143,741	18,834	2,823	152	86	59	22		475	2
San Pedro												
"March"	517	7,423		7,292	131							
"April"	1,235	17,645		17,334	311							
"May"	187	2,621	210	2,306	105							
"June"	109	1,449	116	1,275	58							
"July"	97	760	25	557	152	26						
"August"	2,465	19,956	665	14,635	3,991	665						
"September"	5,512	45,963	1,416	31,468	7,425	2,827	2,473	354				
"October"	451	3,855	119	2,639	623	237	207	30				
Totals, San Pedro	10,573	99,672	2,551	77,506	12,796	3,755	2,680	384				
Grand totals	22,030	265,866	146,292	96,340	15,619	3,907	2,766	443	22		475	2

TABLE 4

Number of Fish, Mean Length and Standard Error of the Mean for Each Year-Class for Monterey and for San Pedro 1948 Interseason

Year-class	Monterey			San Pedro		
	No.	M.	S.E.	No.	M.	S.E.
1947						
Male	180	166	.71	8	177	3.52
Female	148	167	.82	2	188	4.00
Totals	328	166	.54	10	179	3.20
1946						
Male	24	182	2.30	155	181	.92
Female	20	181	2.83	188	184	.89
Totals	44	182	1.78	344[1]	182	.64
1945						
Male	2	210	8.00	18	199	2.86
Female	4	196	11.49	20	204	2.82
Totals	6	201	8.04	38	202	2.01
1944						
Male				5	208	7.16
Female				5	208	3.31
Totals				10	208	2.30
1943						
Male				3	221	1.33
Female				4	220	6.08
Totals				7	221	3.29
1942						
Male						
Female				1	222	----
Totals				1	222	----
1939						
Male						
Female	1	272	----			
Totals	1	272	----			

[1] Includes one fish, length unknown.

TABLE 5

Length Composition of the 1946, 1945, 1944 and 1943 Year-Classes by Areas in the Pacific Northwest in 1948

(Samples from Oregon Only)

Area	1946 Year-class, age 2			1945 Year-class, age 3			1944 Year-class, age 4												1943 Year-class, age 5											
	Unrecorded			Unrecorded			V			VI			VII			Total			V			VI			VII			Total		
Length mm.	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
202	--	1	1																											
234																						1	--	1				1	--	1
236																														
238																														
240																									1	--	1	1	--	1
242																														
244																			1	--	1							1	--	1
246				1	--	1													--	1	1	2	--	2	--	1	1	2	2	4
248													1	--	1	1	--	1				1	--	1				1	--	1
250													1	--	1	1	--	1	2	--	2	1	--	1	2	--	2	5	--	5
252																			--	2	2	2	--	2				2	2	4
254							--	2	2				--	1	1	--	3	3				1	--	1	1	2	3	2	2	4
256				--	1	1													1	1	2	--	1	1	--	1	1	1	3	4
258							--	1	1	--	1	1	--	2	2	--	2	2	--	2	2	1	4	5	--	2	2	1	8	9
260							--	2	2				--	2	2	--	2	2	1	--	1	1	--	1				2	--	2
262							1	--	1							1	--	1				1	1	2	--	1	1	1	2	3
264													2	--	2	2	--	2				--	2	2				--	2	2
266													1	--	1	1	--	1				--	1	1				--	1	1
268																														
270																			1	1	2							1	1	2
Totals	--	1	1	1	1	2	--	2	2	1	3	4	5	2	7	6	7	13	6	7	13	11	9	20	4	7	11	21	23	44

TABLE 6

Length Composition of the 1942 and 1941 Year-Classes by Areas in the Pacific Northwest in 1948

(Samples from Oregon Only)

Area	1942 Year-class, age 6															1941 Year-class, age 7												
	V			VI			VII			Unrecorded			Total			V			VI			VII			Unrecorded			Total		
Length mm.	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
232																						1	--	1				1	--	1
234																														
236																														
238																														
240																														
242										1	--	1	1	--	1															
244				1	--	1							1	--	1	1	--	1				1	--	1				2	--	2
246										1	--	1	1	--	1															
248	1	--	1	2	--	2							3	--	3															
250				1	1	2				1	--	1	2	1	3															
252	1	--	1										1	--	1	--	1	1	1	--	1							1	1	2
254	--	1	1	2	4	6	1	1	2				3	6	9	1	--	1										1	1	2
256	--	1	1	1	--	1	2	1	3				3	2	5	--	2	2										--	2	2
258	1	--	1	--	1	1							1	1	2	--	1	1				1	2	3				1	3	4
260	1	--	1	1	--	1	--	1	1	--	1	1	2	2	4	1	--	1	1	1	2	1	1	2				3	2	5
262	1	1	2										1	1	2				--	2	2							--	2	2
264	1	--	1	--	1	1							1	1	2	1	1	2				1	--	1				2	1	3
266	--	1	1										--	1	1				--	1	1							--	1	1
268	--	1	1	--	1	1							--	2	2							--	1	1				--	1	1
270							1	1	2				1	1	2															
272	1	--	1	--	1	1							1	1	2							--	1	1				--	1	1
274							--	1	1				--	1	1							--	1	1				--	1	1
276																						--	1	1				--	1	1
278	--	1	1	1	--	1							1	1	2															
Totals	7	6	13	9	9	18	4	5	9	3	1	4	23	21	44	4	5	9	2	4	6	5	7	12	--	1	1	11	17	28

TABLE 7

Length Composition of the 1940, 1939 and 1938 Year-Classes by Areas in the Pacific Northwest in 1948

(Samples from Oregon Only)

Area	1940 Year-class, age 8												1939 Year-class, age 9												1938 Year-class, age 10		
	V			VI			VII			Unrecorded			Total			V			VI			VII			Unrecorded			Total			V		
Length mm.	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
248																									1	--	1	1	--	1			
250							--	1	1				--	1	1																		
252							--	1	1				--	1	1				1	--	1							1	--	1			
254	1	--	1										1	--	1																		
256	1	1	2	--	1	1	--	3	3				1	5	6	--	2	2	--	1	1							--	3	3			
258				1	--	1	2	1	3				3	1	4				--	1	1							--	1	1			
260	--	2	2	2	3	5	1	--	1				3	5	8																		
262	--	1	1	1	1	2							1	2	3	--	1	1										--	1	1			
264	--	2	2	1	--	1	1	--	1				2	2	4				1	--	1	1	--	1				2	--	2			
266				--	1	1	1	--	1	--	1	1	1	2	3	1	--	1										1	--	1			
268				1	2	3							1	2	3	1	--	1	--	1	1	--	1	1				1	2	3			
270	--	1	1	1	1	2							1	2	3																		
272				--	1	1							--	1	1																		
274	--	1	1										--	1	1																1	--	1
276	--	2	2										--	2	2	1	1	2										1	1	2			
278																1	--	1										1	--	1			
Totals	2	10	12	7	10	17	5	6	11	--	1	1	14	27	41	4	4	8	2	3	5	1	1	2	1	--	1	8	8	16	1	--	1

TABLE 8

Length Composition of the 1948, 1947 and 1946 Year-Classes in 1948-49

Length mm.	1948 Year-class, age 0			1947 Year-class, age 1									1946 Year-class, age 2														
	Grand Total[1]			Monterey			San Pedro			Grand Total[2]			Pacific Northwest[3]			Monterey			San Pedro			California			Grand Total		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
140				1	1	2				1	1	2															
142																											
144																											
146				1	3	4				1	3	4															
148					1	1					1	1															
150				4	4	8				4	4	8															
152				10	4	14				10	4	14															
154				8	4	12				8	4	12															
156				2		2				2		2															
158		1	1	6	7	13		2	2	6	9	15															
160				9	8	17		1	1	9	9	18															
162				8	15	23		2	2	8	17	25															
164				11	13	24				11	13	24															
166				12	11	23	1	1	2	13	12	25															
168				12	11	23	1	1	2	13	12	25															
170				14	10	24				14	10	24				1		1				1		1	1		1
172				16	10	26	1		1	17	10	27															
174				20	14	34		1	1	20	15	35															
176				12	8	20				12	8	20															
178				17	17	34				17	17	34															
180				23	9	32	1		1	24	9	33				1		1				1		1	1		1
182				15	10	25	1	1	2	16	11	27															
184				24	17	41	1	1	2	25	18	43				2	1	3	2	1	3	4	2	6	4	2	6
186				24	14	38	2	2	4	26	16	42				2	3	5	3	2	5	5	5	10	5	5	10
188				22	12	34	1	1	2	23	13	36				2	1	3	8	4	12	10	5	15	10	5	15

190				13	15	28	5	4	9	18	19	37				1	1	2	18	7	25	19	8	27	19	8	27
192				13	16	29	6	1	7	19	17	36				3	4	7	15	7	22	18	11	29	18	11	29
194				16	11	27	2	5	7	18	16	34				---	3	3	17	23	40	17	26	43	17	26	43
196				14	11	25	2	1	3	16	12	28				1	2	3	18	24	42	19	26	45	19	26	45
198				7	7	14	---	5	5	7	12	19				4	4	8	25	33	58	29	37	66	29	37	66
200				4	4	8	1	3	4	5	7	12				2	2	4	27	32	59	29	34	63	29	34	63
202				2	1	3	1	---	1	3	1	4	---	1	1	3	2	5	12	29	41	15	31	46	15	32	47
204				2	1	3	---	1	1	2	2	4				3	1	4	11	22	33	14	23	37	14	23	37
206				---	1	1				---	1	1				2	2	4	9	23	32	11	25	36	11	25	36
208																---	3	3	5	9	14	5	12	17	5	12	17
210																---	1	1	3	7	10	3	8	11	3	8	11
212																1	---	1	---	5	5	1	5	6	1	5	6
214																			1	2	3	1	2	3	1	2	3
216																			---	2	2	---	2	2	---	2	2
218																---	1	1	---	1	1	---	2	2	---	2	2
232																1	---	1				1	---	1	1	---	1
Totals	---	1	1	342	270	612	26	33	59	368	303	671	---	1	1	29	31	60	174	233	407	203	264	467	203	265	468

[1] Year-class represented in California only at Monterey.
[2] Year-class represented in California only.
[3] Pacific Northwest represented by Oregon only.

TABLE 9

Length Composition of the 1945 and 1944 Year-Classes in 1948-49

Length mm.	1945 Year-class, age 3												1944 Year-class, age 4											
	Pacific Northwest[1]			Monterey			San Pedro			California			Grand Total			Pacific Northwest[1]			Monterey			San Pedro			California			Grand Total		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
186							1	---	1	1	---	1	1	---	1															
188																														
190																														
192																														
194							---	1	1	---	1	1	---	1	1															
196							2	1	3	2	1	3	2	1	3															
198							2	---	2	2	---	2	2	---	2															
200							6	---	6	6	---	6	6	---	6							2	---	2	2	---	2	2	---	2
202							3	2	5	3	2	5	3	2	5							3	---	3	3	---	3	3	---	3
204							1	6	7	1	6	7	1	6	7							1	2	3	1	2	3	1	2	3
206							3	5	8	3	5	8	3	5	8							2	---	2	2	---	2	2	---	2
208					1	1	3	2	5	3	3	6	3	3	6							1	---	1	1	---	1	1	---	1
210					1	1	8	11	19	8	12	20	8	12	20							2	1	3	2	1	3	2	1	3
212					1	1	3	8	11	3	9	12	3	9	12							1	4	5	1	4	5	1	4	5
214							1	8	9	1	8	9	1	8	9							1	2	3	1	2	3	1	2	3
216							2	4	6	2	4	6	2	4	6							---	2	2	---	2	2	---	2	2
218							4	6	10	4	6	10	4	6	10							1	---	1	1	---	1	1	---	1
220				2	2	4	1	2	3	3	4	7	3	4	7							1	1	2	1	1	2	1	1	2
222				1	1	2				1	1	2	1	1	2				1	---	1	2	2	4	3	2	5	3	2	5
224				---	2	2				---	2	2	---	2	2				1	---	1				1	---	1	1	---	1
226				2	---	2	---	2	2	2	2	4	2	2	4															
228				---	1	1				---	1	1	---	1	1				1	---	1	1	---	1	2	---	2	2	---	2
230				1	1	2	---	1	1	1	2	3	1	2	3															
232				1	2	3				1	2	3	1	2	3															
234				---	1	1				---	1	1	---	1	1				1	---	1				1	---	1	1	---	1
236				1	---	1				1	---	1	1	---	1															
238				1	1	2				1	1	2	1	1	2				---	2	2				---	2	2	---	2	2

240					1	1					1	1		1	1														
242																													
244																													
246	1		1										1		1														
248																													
250																1		1										1		1
252																1		1			1	1		1	1	1		1	1	2
254																													
256			1	1										3	3													3	3
258														1	1														
260														2	2													2	2
262														2	2													2	2
264													1		1													1	1
266													2		2													2	2
													1		1													1	1
Totals	1	1	2	9	15	24	40	59	99	49	74	123	50	75	125	6	7	13	4	2	6	18	15	33	22	17	39	28	24	52

[1] Pacific Northwest represented by Oregon only.

TABLE 10

Length Composition of the 1943, 1942, 1941, 1940, 1939 and 1938 Year-Classes in 1948-49

Length mm.	1943 Year-class, age 5												1942 Year-class, age 6									1941 Year-class, age 7			1940 Year-class, age 8			1939 Year-class, age 9			1938 Year-class, age10		
	Pacific Northwest[1]			Monterey			San Pedro			California			Grand Total			Pacific Northwest[1]			California[2]			Grand Total			Grand Total[3]			Grand Total[3]			Grand Total[3]			Grand Total[3]		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
214							2	--	2	2	--	2	2	--	2																			
216							1	1	2	1	1	2	1	1	2																			
218							1	1	2	1	1	2	1	1	2																			
220							--	1	1	--	1	1	--	1	1																			
222																																	
224							--	1	1	--	1	1	--	1	1																			
226																																	
228							1	--	1	1	--	1	1	--	1																			
230																																	
232																						1	--	1									
234	1	--	1										1	--	1																		
236																																	
238																																	
240	1	--	1										1	--	1																		
242																1	--	1				1	--	1									
244	1	--	1										1	--	1	1	--	1				1	--	1	2	--	2						
246	2	2	4										2	2	4	1	--	1	1	--	1	2	--	2									
248	1	--	1										1	--	1	3	--	3				3	--	3				1	--	1			
250	5	--	5										5	--	5	2	1	3				2	1	3				--	1	1			
252	2	2	4										2	2	4	1	--	1				1	--	1	1	1	2	--	1	1	1	--	1
254	2	2	4										2	2	4	3	6	9				3	6	9	1	1	2	1	--	1			
256	1	3	4										1	3	4	3	2	5				3	2	5	--	2	2	1	5	6	--	3	3
258	1	8	9	1	--	1				1	--	1	2	8	10	1	1	2				1	1	2	1	3	4	3	1	4	--	1	1
260	2	--	2										2	--	2	2	2	4				2	2	4	3	2	5	3	5	8			
262	1	2	3										1	2	3	1	1	2				1	1	2	--	2	2	1	2	3	--	1	1
264	--	2	2										--	2	2	1	1	2				1	1	2	2	1	3	2	2	4	2	--	2
266	--	1	1										--	1	1	--	1	1				--	1	1	--	1	1	1	2	3	1	--	1
268																--	2	2				--	2	2	--	1	1	1	2	3	1	2	3
270	1	1	2										1	1	2	1	1	2				1	1	2				1	2	3			
272																1	1	2				1	1	2	--	1	1	--	1	1			
274																--	1	1				--	1	1	--	1	1	--	1	1	1	--	1
276																									--	1	1	--	2	2	1	1	2
278																1	1	2				1	1	2							1	--	1
Totals	21	23	44	1	--	1	5	4	9	6	4	10	27	27	54	23	21	44	1	--	1	24	21	45	11	17	28	14	27	41	8	8	16	1	--	1

[1] Pacific Northwest represented by Oregon only.
[2] Year-class represented in California only at San Pedro.
[3] Year-class represented in Oregon only.

TABLE 11

Number of Fish, Mean Length, and Standard Error of the Mean for Each Year-Class in 1948-49 by Region of Catch

Year-class	Pacific Northwest[1]			California					
				Monterey[2]			San Pedro		
	No.	M.	S.E.	No.	M.	S.E.	No.	M.	S.E.
1948									
Male									
Female				1	158	----			
Totals				1	158	----			
1947									
Male				342	178	.70	26	188	1.72
Female				270	177	.82	33	186	2.48
Totals				612	178	.54	59	187	1.58
1946									
Male				29	196	2.14	174	197	.44
Female	1	202	----	31	198	1.48	233	200	.40
Totals	1	202	----	60	197	1.28	407	199	.30
1945									
Male	1	246	----	9	228	2.22	40	207	1.18
Female	1	256	----	15	225	2.53	59	211	.87
Totals	2	251	5.00	24	226	1.78	99	210	.73
1944									
Male	6	259	3.22	4	227	2.65	18	210	2.04
Female	7	257	1.47	2	238	----	15	216	2.78
Totals	13	258	1.67	6	231	2.85	33	213	1.73
1943									
Male	21	252	1.74	1	258	----	5	218	2.60
Female	23	258	1.19				4	220	1.73
Totals	44	255	1.10	1	258	----	9	219	1.56
1942									
Male	23	256	1.88				1	246	----
Female	21	262	1.74						
Totals	44	258	1.34				1	246	----
1941									
Male	11	254	3.03						
Female	17	262	1.70						
Totals	28	259	1.73						
1940									
Male	14	261	1.22						
Female	27	263	1.37						
Totals	41	262	.98						
1939									
Male	8	264	3.70						
Female	8	262	2.64						
Totals	16	264	2.24						
1938									
Male	1	274	----						
Female									
Totals	1	274	----						

[1] Samples from Oregon only.
[2] Monterey represented by local fish only. Fish trucked from Southern California not sampled at Monterey.

TABLE 12

Calendar Dates of Lunar Months for the 1948 Interseason and 1948-49 Season

"April"----------March 26-April 23
"May"----------April 24-May 23
"June"----------May 24-June 21
"July"----------June 22-July 21
"August"----------July 22-August 19
"September"---August 20-September 17
"October"-----September 18-October 16
"November"---October 17-November 15
"December"--November 16-December 14
"January"----December 15-January 13
"February"----January 14-February 12

TABLE 13

Age (Year-class) Composition of the Sardine Catch in the 1948-49 Season
(Numbers of Fish Are Given in Thousands, i.e., 000 Omitted)

	Catch		Number of fish by age (year-class)										
			0	1	2	3	4	5	6	7	8	9	10
	Tons	Number	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938
Pacific Northwest—Totals[1]	5,500	22,281			118	234	1,524	5,161	5,160	3,284	4,808	1,876	116
California—													
San Francisco													
Totals, San Francisco Local[2]	499	6,736	9	5,855	577	229	57	9					
Totals, San Francisco-So. Calif.	870	7,350		713	4,920	1,197	399	109	12				
Totals, San Francisco	1,369	14,086	9	6,568	5,497	1,426	456	118	12				
Monterey													
"August"—Local	3,213	38,546		33,408	4,498		320	320					
"September"													
Local	10,267	119,671		110,097	7,779	1,795							
Southern California	202	1,658		51	1,135	268	102	89	13				
Totals, "September"	10,469	121,329		110,148	8,914	2,063	102	89	13				
"October"													
Local	12,559	152,039		139,632	11,373	1,034							
Southern California	2,015	16,417		2,290	9,163	2,801	1,781	254	128				
Totals, "October"	14,574	168,456		141,922	20,536	3,835	1,781	254	128				
"November"													
Local	787	8,585		7,697	888								
Southern California	180	1,556		31	1,167	280	31	47					
Totals, "November"	967	10,141		7,728	2,055	280	31	47					
"December"													
Local	7,827	106,207	712	96,223	8,560	712							
Southern California	991	8,833		711	6,876	890	238	118					
Totals, "December"	8,818	115,040	712	96,934	15,436	1,602	238	118					

"January"													
Local	52	319		22	42	202	53						
Southern California	1,492	13,098		1,064	8,514	2,538	901	81					
Totals, "January"	1,544	13,417		1,086	8,556	2,740	954	81					
"February"—So. Calif.	841	7,730		1,546	4,417	1,435	221	111					
Totals, Monterey Local	34,705	425,367	712	387,079	33,140	3,743	373	320					
Totals, Monterey-So. Calif.	5,721	49,292		5,693	31,272	8,212	3,274	700	141				
Totals, Monterey combined	40,426	474,659	712	392,772	64,412	11,955	3,647	1,020	141				
San Pedro[3]													
"October"	30,450	248,646		34,686	138,770	42,419	26,978	3,854	1,939				
"November"	12,830	106,761		2,135	80,071	19,217	2,135	3,203					
"December"	44,376	394,071		31,723	306,783	39,683	10,601	5,281					
"January"	17,809	149,457		12,136	97,147	28,964	10,283	927					
"February"	9,444	86,984		17,397	49,702	16,153	2,488	1,244					
Totals, San Pedro	114,909	985,919		98,077	672,473	146,436	52,485	14,509	1,939				
San Diego[4]	2,940	25,187		2,443	16,862	4,101	1,368	373	40				
Totals, California	159,644	1,499,851	721	499,860	759,244	163,918	57,956	16,020	2,132				
Grand Totals, Pacific Coast	165,144	1,522,132	721	499,860	759,362	164,152	59,480	21,181	7,292	3,284	4,808	1,876	116

[1] Oregon only.
[2] Includes some fish trucked from Montery. All values for San Francisco, except tons landed, were prorated from Monterey totals.
[3] Includes some fish processed at Hueneme and about 890 tons trucked from San Diego to San Pedro.
[4] All values for San Diego, except tons landed, were prorated from San Pedro totals.

THE 1948-49 OUTBREAK OF FOWL CHOLERA IN BIRDS IN THE SAN FRANCISCO BAY AREA AND SURROUNDING COUNTIES[1]

By MERTON N. ROSEN [2] and ARTHUR I. BISCHOFF [2]

INTRODUCTION AND HISTORY

Fowl cholera is a disease commonly associated with chickens, turkeys, and other domestic poultry. The losses in ducklings on duck ranches in the State of Rhode Island are heavy, according to Hagan (1943). However, the disease has been thought to be decreasing in incidence in the United States, especially in the heavy poultry sections of the midwest.

The records of the Disease Laboratory of the California Division of Fish and Game recognized the occurrence of fowl cholera in wild ducks circa January, 1944. At that time Herman visited the Bethel Tract near Oakley and observed 1,000 dead coots. This outbreak occurred immediately following losses of domestic fowl in the area. There are indications that fowl cholera had occurred in wild ducks in the Mt. Eden area of South San Francisco Bay just prior to Herman's report of 1944. No records of the disease in wild birds during 1945 and 1946 were obtainable; however, farmers in the delta and south bay areas reported extensive waterfowl losses during those years. The fish and game records again refer to fowl cholera outbreaks in 1947 and 1948 from the Alviso area to the slough and island areas of the San Joaquin Delta.

CAUSATIVE ORGANISM

The organism responsible for fowl cholera is the small, oval, gram-negative bacterium, *Pasteurella multocida*. When it is seen in a blood smear strained by Wright's method, it is distinctly bipolar; Pasteur referred to it as the "figure of eight" bacillus. Some strains of the organism will grow with more or less difficulty on agar. The more virulent bacilli are the more fastidious in that they require agar enriched with blood or serum for growth. The strain isolated during the 1949 epizootic by the authors would grow best on a blood or serum enriched medium. There are three types of colonies: The fluorescent is associated with epizootics of fowl cholera; the blue type occurs where the disease is enzootic or chronic; and a third intermediate type seems to be connected with outbreaks of severe cholera. The colonies isolated in the recent outbreak were of the last type.

The biochemical reactions are in dispute, and some authors feel that sugar fermentation capabilities can be correlated with virulence of the

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strain, whereas other authors feel that the biochemical reactions are connected with host specificity. The virulence of the organism isolated from a canvas-back duck at Lake Merritt is known by the rapidity and unfailing effect with which death overtakes any experimental animal which ingests it. This strain does not ferment lactose, but does ferment glucose, arabinose, dulcitol, and xylose with production of acid but not gas. It produces indol after 48 hours incubation.

SYMPTOMS

In the explosive type of outbreak in poultry, all birds may be apparently healthy at night, but many may be found dead under the roosts on the following morning. No indicative symptoms precede death. This also was found to be the case in the beginning of the recent fowl cholera epizootic. No sick waterfowl could be seen for a period of one week to ten days after the onset of the disease. The birds were observed either in normal flight or loafing attitude, or else the carcasses were seen floating on the ponds or lying along the shoreline. After the first seven to ten days, a few, and later more and more waterfowl could be seen demonstating various symptoms. Indeed, the symptoms started by a few ducks appearing to be in a stupor, later becoming more diversified in such extremes as the inability to get off the water or an uncontrolled tumbling while in flight. Two ducks were observed gliding in for landings and folded their wings fully twenty feet above the water, crashing with great geysers of spray. Many of the wild birds slumped on the shore could be approached and picked up without showing any effort to escape. Others waddled away as best they could in their condition. Many birds were

FIGURE 46. Typical picture of severe bacteremia in blood smear of duck after death from fowl cholorea. Arrows show characteristic "figure 8" organisms. X 3,000. *Photo by John Azevedo*

unable to hold up their heads, exhibiting the symptoms usually associated with botulism; if they were in shallow water, several would die of drowning before death from the disease could occur. Some sick coots and gulls did not attempt to get away but used the only defense remaining: snapping at the collectors. As the disease progressed diarrhea became more frequent in the waterfowl, producing watery greenish droppings. This condition is indicative of any disease affecting the intestinal tract.

PATHOLOGY

Minute hemorrhages occur on most of the mucous membranes. These petechial hemorrhages are most noticeable on the epicardium and myocardium. Focal necrosis occurs in the liver in the form of pinhead white or grey specks, this condition occurring with more frequency when the virulence of the organism has dropped in the last stages of an epizootic or the resistance of the host has been increased so that a longer course of disease is possible within the bird. Likewise, the tail end of the outbreak is indicated by the undulating flight of the ducks which is caused by an otitis media, with a pus formation in the middle ear frequently extending through the canals leading through the inner ear to the base of the brain. Septicemia is the result of blood vessel invasion by myriads of organisms: A true bacteremia is seen in the illustration (Fig. 46).

TRANSMISSION AND EPIDEMIOLOGY

Biester and Schwarte (1948) state that the infection is passed off by diseased birds through their excrement which contaminates soil, food and water. Gulls have been observed eating carcasses of other birds that have died of fowl cholera. Undoubtedly this scavenger practice contributes greatly to the rapid and widespread transmission of the disease. Although several authors maintain that feeding infectious material rarely produces the disease, 38 consecutive passages in coots were successful when employing intrapharyngeal instillation of a heart blood saline mixture. The coots would die within eight hours. However, the initial explosive outbreak of the disease remains unexplained by the above observations. It has been determined that the organism is harbored by apparently healthy animals in their respiratory tract. Merchant (1940) claims that droplet infection is of significance. Pritchet et al. (1930, 1932) isolated the infectious agent from the upper respiratory tract of supposedly normal birds and produced typical cholera in susceptible fowl. In Holland, Van der Hurk (1946) observed an epizootic of cholera that started with the arrival of wild ducks and caused a heavy mortality not only among their own numbers but to the domestic poultry of the country.

A mouse inoculated intraperitoneally with 0.5 cc. of water taken from a pond where many waterfowl had died, succumbed four hours after inoculation with prior symptoms of dyspnea and lacrimation. A blood smear revealed the typical bipolar organisms of fowl cholera. Confirmation was obtained by isolation of a pure culture of the organism. Fresh flights of ducks continued to pour into this particular pond. Gulls congregated along the shore devouring the carcasses of the mudhens and ducks. A cat was found dead with true secondary infection when the remains of a coot were found in his stomach.

Coots made up the greatest number of dead birds. Apparently the mudhen is more susceptible than any other waterfowl. In the outbreaks

observed by the authors, these birds made up from 70 to 100 percent of the mortality. Ducks of various species made up 10 to 20 percent of the total deaths, with gulls following closely with a mortality of 5 to 10 percent. Of the ducks the spoonbill was the most susceptible and the mallards were the least susceptible. Widgeon followed closely behind the spoonbill in high mortality rate, with the canvasback, teal, and sprig following in that sequence. A few shorebirds, phalarope, blue heron, tern, and sandpiper, also died of the disease. The so-called "susceptibility" is probably due to feeding habits rather than any innate decrease in resistance or relative immunity. The mortality rates are based on an equal distribution of numbers of the different species. It is felt that the gull is fairly resistant because they were the first sick birds observed after the start of the epizootic, and a few were observed to remain alive for a period of twenty-four hours while other birds were dying in less than ten hours. Many sick gulls were seen gliding in flight for two or three miles and landing in distant ponds. The gull movement may well be one of the principal modes of transmitting the disease to new areas. The authors have observed the diseased gulls in areas prior to death of any waterfowl.

On the seventh of December, 1948, the laboratory was notified that ducks were dying in the vicinity of Alviso. Experimental mice were inoculated with heart blood of the dead ducks. Within four hours pure culture material of *Pasteurella multocida* was obtained from the blood stream. Domestic ducks were inoculated with the infectious material and the virulence of the organism was established with the death of the ducks in from six to eight hours. The site of the outbreak was immediately adjacent to the San Jose garbage dumps where hundreds of gulls congregated to eat the offal. With the realization that this epornitic had the potential to devastate large numbers of ducks through its high virulence and by ease of transmission through the large number of gulls that were in the area which would be succumbing to the disease, a reconnaissance was made of the duck ponds to the north of Alviso. No evidence of northward spread of fowl cholera could be found in the Irvington and Newark areas at the time.

At the start of the second week of the epizootic, it was found that fowl cholera was killing ducks, coots, and gulls beyond Irvington—approximately six miles north of the initial point at Alviso. More and more ponds were being flooded around Alviso and to the north as far as Alvarado (15 miles airline from the focal point), to attract ducks as the forthcoming hunting season grew nearer. This not only provided impetus for new flights to land but served to scatter those birds exposed to the disease. Within ten days of the initial outbreak, coots by the hundreds were being picked up near the Leslie salt ponds at Newark. One small pond of six acre-feet yielded a collection of six hundred dead ducks just a few days after the disease broke out on it. The ponds involved in the initial outbreak continued to cause the death of thirty to forty ducks per day. Several thousand ducks were succumbing to fowl cholera as the second half of the duck season began. The northward spread continued with reports of dead ducks extending up the west side of the bay from Sunnyvale to Millbrae. Storms and hunting pressure seem to have lessened the mortality about Alviso temporarily. Ducks scattered before the concentrated assault of the sportsmen. Some of the waterfowl apparently sought refuge in the sanctuary of Lake Merritt in Oakland.

The disease started in this city lake with fifteen to twenty ducks per day being picked up. A decline in mortality to seven per day two weeks after the onset of the epizootic, and then in three weeks a sudden increase to 30 ducks a day mortality occurred. The losses continued until the beginning of April.

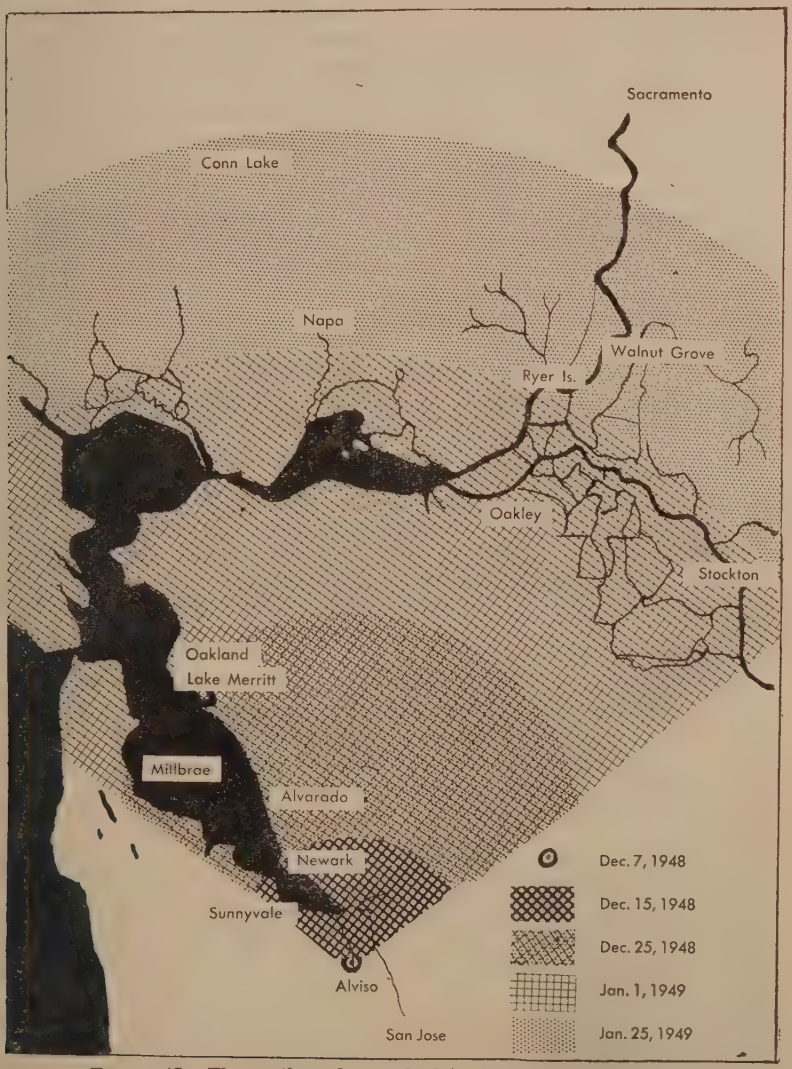

FIGURE 47. The northward spread of fowl cholera in wild birds during the 1948-49 outbreak

The death wave continued to fan out as illustrated in the accompanying map. Near Prospect and Ryer Islands on the Rio Farms of the delta 15 ducks were picked up in one hour along a drainage ditch. Mortality in this area dropped following the close of the season, and by the

end of January an all-day search resulted in finding 50 coots, some of which were very much decomposed. On the north and west the disease continued by breaking out at Conn Lake in Napa County on about January 25th. This outbreak involved at least one thousand five hundred waterfowl, 90 percent of which were coots. The disease waned about the middle of February.

An outbreak of cholera was investigated in the area south of Walnut Grove and west of Lodi in which the losses were primarily swans with very few coots and apparently no ducks. Approximately one hundred carcasses were observed. How the disease was transmitted to these birds is a matter of conjecture. The theory that apparently healthy birds may carry the organism and succumb to it when the resistance of the host is lowered may account for this outbreak.

The northward migration of the waterfowl leaving the diseased areas terminated reports of losses from fowl cholera. Observers of the Division of Fish and Game stationed in the Sacramento Valley noted the arrival of the northward migrating birds, and, warned of the possibility of fowl cholera being transmitted along the flyway, kept a careful watch for the disease.*

CONTROL AND PREVENTION

In domestic poultry, when confronted with a severe outbreak resulting in heavy losses, the recommended procedure is depopulation except where the disease is so well established as to present a problem of recurrence. The premises should not be repopulated until the natural purification of sun and air has had enough time to take effect. Draining of water is a recommended procedure. All carcasses should be carefully collected and burned. Disinfectant is applied to the walls, roosts, nests, feed and water containers as liquor cresolis, formalin, or lye.

Some of the above procedures have an analogy in fowl cholera as it occurs in the wild as modified by practicability and economic considerations.

The immediate suggestion to cooperating individuals such as caretakers of private or commercial duck clubs, farmers, and sportsmen is to pick up all carcasses and effectively dispose of them by burning. The gross contamination of the environment and the continually increasing concentration of organisms is thereby combatted to some extent.

As the initial confirmed diagnosis of fowl cholera was made at the four ponds near Alviso, and based on the reproduction of the disease in mice through the inoculation of the pond water, a recommendation was made that those particular ponds serving as the infectious focal point be drained on an experimental basis. It was thought that this procedure would effectively dispose of the contaminated water and prevent fresh flights of ducks from entering the diseased area. The owner of one of the ponds complied with the request and drained all water from his ponds. An owner of a duck pond 200 feet distant from these drained, agreed to act as the control base and retain his ponds in their flooded state since his pump did not have the capacity to refill his pond in time for the

* Since this manuscript was prepared the authors learned of mortality among ducks at the Sacramento Waterfowl Refuge of the U. S. Fish and Wildlife Service near Willows, California. The outbreak apparently reached its peak about March 21st. An estimated 2,000 birds were on the pond where the losses occurred. Between 100 and 150 ducks succumbed. A diagnosis of fowl cholera was made on a sample of these birds by the pathology laboratory of the California Bureau of Animal Industry.

opening of the second half of the duck season. He continued to pick up from thirty to forty dead ducks each day.

A concentration of 1:5000 solution of copper sulfate was mixed with infectious blood in a test tube. Experimental animals were inoculated with the mixture after intervals of 15 minutes, 30 minutes, and one hour. Those birds injected with the 15- and 30-minute mixtures succumbed within a few hours after treatment whereas those inoculated with the hour mixture survived. The experiment was carried into the field with the procurement of 4,600 pounds of copper sulfate. Two tons were dissolved in drums with the aid of hydrochloric acid and mixed with water that was refilling the ponds that had been drained. Six hundred pounds were used to treat the water in an infected pond near Sunnyvale. Three days after treatment, water samples were collected and concentrated in an ultracentrifuge at 17,000 revolutions per minute. The concentrates were inoculated into mice without effect. Inasmuch as this treated water had been fresh and no further deaths had occurred between the time of treatment and the procurement of samples for concentration, a conclusion as to the efficacy of this experiment cannot be drawn. A survey of the south bay disease areas disclosed a small residue of infection in the coots and gulls, but the severity of the initial infection had disappeared. Storms and hunting pressure and with the attendant movement of duck populations, possible decline of virulence in the organism had brought about a temporary lowering of the mortality rate.

On being apprised of the appearance of fowl cholera in Lake Merritt, the cooperation of the City of Oakland was solicited, in order that the lake might be flushed out by opening the flood gates leading into the estuary and bay. Salt water was allowed to flow into the lake by letting the flood gates remain open during high tide. The disease continued with a slight decrease in mortality. This procedure was initiated with the hope that a noticeable effect of salt water on the organism would result, based on the observation that while fresh water ponds near Alviso had heavy losses of waterfowl upon them, the salt water ponds and marshes had no observable losses.

SUMMARY AND CONCLUSIONS

An epizootic of fowl cholera started during the first week of December, 1948, on fresh water ponds at the south end of San Francisco Bay near Alviso. This outbreak was thought to be a continuation of similar ones which had occurred during the winter of each of the preceding four years.

The causative organism was a virulent strain of *Pasteurella multocida* that would grow best on a blood or serum enriched medium. It proved to be of the intermediate or Group III type in that it did not ferment lactose, but fermented glucose, arabinose, dulcitol, and xylose with the production of acid but no gas. Characteristically, indol was produced.

At the beginning of the outbreak no symptoms were observed in the waterfowl: they were either dead or alive. Symptoms of the disease became apparent during the second week of the epizootic with sick birds huddled on the shoreline unable to fly, several drowning in shallow water through the inability to hold up their heads, or tumbling or undulating in flight. Greenish diarrhea became prominent among the birds slumped

along the shoreline. Autopsied ducks showed minute hemorrhage of the heart with some reddening of the intestinal tract. In the last stages of the outbreak some swans had the pin-point, grey necrotic foci in the liver. Microscopically, the multitudes of bacteria in the blood stream could be easily demonstrated.

The scavenger habits of gulls eating the carcasses of waterfowl that had died of the disease seemed to contribute greatly to the rapid and widespread transmission of the disease. Proof of the infectivity of the water was obtained by the death of a mouse that had been inoculated intraperitoneally with 0.5 cc. of water taken from a pond where many waterfowl had died.

The spread of the epizootic was traced from the focal point at Alviso gradually north through Lake Merritt and on up through the delta. Approximately forty thousand waterfowl perished from the disease before the northward migration coincided with the end of reports of waterfowl losses.

Acting on the procedures followed by the poultry industry, carcasses were picked up by cooperating individuals and agencies and burned. Depopulation and cleansing of premises were attempted by drainage of a few ponds to prevent fresh flights of ducks from entering those ponds and by disposing of the contaminated water. Experimentally, 4,600 pounds of copper sulfate were used to treat three ponds. The results of this procedure are questionable due to factors which came into play immediately after application. As the disease started in Lake Merritt, the flood gates were opened with the hope that contaminated water would flow out and any disinfectant action that salt water might have could take effect with the introduction of bay water during high tide. No noticeable effect resulted from this action.

All of the experimental control measures were performed under pressure of the epizootic. Circumstantial evidence indicates possible value to the measures applied during the outbreak. Investigations and research are continuing on fowl cholera with the application of field experiments in an effort to determine where the responsibility for initiation of an outbreak lies, on control, and on other factors as they relate to the disease.

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DISEASE INVESTIGATIONS ON MAMMALS AND BIRDS BY THE CALIFORNIA DIVISION OF FISH AND GAME[1]

By CARLTON M. HERMAN [2] and MERTON N. ROSEN [3]
Bureau of Game Conservation
California Division of Fish and Game

During the past 40 years the California Division of Fish and Game has been as active in the study of wildlife diseases as any similar agency in other states. Until recent years the work was intermittent and was discontinued at times for lack of funds or lack of adequately trained personnel. The present program has been in progress since July, 1942.

The earliest disease investigations by the California Division of Fish and Game were undertaken during the period 1911-1913 when Frank C. Clarke was assigned to study deer losses in the north coastal counties of California and duck disease in the San Joaquin Valley.

Following these preliminary studies the program was renewed in 1928 under the jurisdiction of the Bureau of Research. Dr. K. F. Meyer, Director of the Hooper Foundation of the University of California Medical School was appointed consulting pathologist. Dr. Earl C. O'Roke was hired as parasitologist, Dr. Henry Van Roekel as pathologist and Robert J. Irvine as chemist. In 1929 Paul H. Shaw became toxicologist. In this same year Van Roekel and O'Roke resigned to accept positions in the east. In 1930 Dr. M. Hobmaier was appointed pathologist and Gordon H. True, Jr., was indirectly assigned to a temporary position on the staff since part of his assigned duties were to study the relation of deer to growing crops and part to investigate diseases of and their relation to domestic livestock. In 1932 True was assigned to the Bureau of Game Farms in charge of field production of game. Further personnel were not employed by the division for investigations of parasites until the senior author was appointed in July, 1942.

In July, 1933, the financial situation of the division made necessary many extensive cuts in personnel and the entire disease program was discontinued. The toxicologist was maintained on the division staff but his duties were primarily concerned with pollution investigations.

During this period, 1928-1932, the staff made contributions to our knowledge of diseases in captive birds at state game farms, described a malaria parasite of quail, and clarified our knowledge of duck disease in California. The work on duck disease was undoubtedly the most outstanding of this period. After much investigation on the possibilities of alkali poisoning, the studies led to the diagnosis of type C botulism, confirming the findings of the U. S. Biological Survey.

[1] Submitted for publication April, 1949.
[2] Parasitologist, in charge.
[3] Federal Aid in Wildlife Restoration Act, California Project 35R.

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In 1938 the junior author, who had been working on the pollution detail, was assigned to study botulism. This work was discontinued two years later when Rosen was granted leave of absence for military duty. In July, 1942, the senior author was appointed in charge of the disease investigations of the Bureau of Game Conservation.

During the period 1928-1932, laboratory facilities were made available at the Hooper Foundation. In 1938 Rosen had available facilities at the Hooper Foundation but prior to his leave of absence laboratory facilities were housed in a one-room structure on the pier at the Ferry Building in San Francisco. The program in 1942 was renewed with these inadequate facilities. In April, 1945, the U. S. Navy took over the location of the laboratory and temporary quarters were obtained in the Life Sciences Building on the campus of the University of California in Berkeley. In August, 1945, the activities were moved to our present quarters in a remodeled CCC Building on the campus in Strawberry Canyon. These facilities are shared with the food habits study project 25R which is a part of the federal aid program of the division.

Both staff and equipment of the disease investigations project have been increased gradually until at present we have a good working unit. Rosen returned in February, 1946, and is now senior bacteriologist. Recently work has been divided and part of the program is carried as Federal Aid in Wildlife Restoration Project California 35R, "A Study of Diseases of Wildlife Species in California." The staff for this phase of work includes Merton N. Rosen, senior bacteriologist; Arthur I. Bischoff, laboratory technician; John Azevedo, laboratory assistant; and Burke Zane, laboratory helper. The last employee is on a half-time basis. The remainder of the staff includes, Carlton M. Herman, parasitologist, in charge; Alvin Hightower, hunter and trapper; Barry Tarshis and Kenji Sayama, laboratory assistants on a half-time basis; and Mildred I. Goodman, intermediate stenographer-clerk.

TYPES OF INVESTIGATIONS

Several types of investigations are undertaken by the staff of the laboratory. All of these have specific purposes for which they are designed. Incidence studies are fundamental in determining the importance of particular parasites or diseases. Methods of employing management practices in controlling disease is another phase of the work. The laboratory may be employed as a service for cooperation with management of particular species or range in using certain testing methods. Control of disease under captive conditions such as the state game farms may be employed, e.g. blood testing of breeding stock. Investigations can lead to employment of field experiments and recommendations as a result of those experiments. Primary examples are presented in the work that has been and is being done.

One of the first projects undertaken in 1942 was a study of the parasites of quail. One phase of our investigations on coccidia has been completed and published, indicating that these intestinal protozoa are of widespread occurrence in the wild birds. It was also determined that these parasites take a toll of quail and chukar partridge at some of the game farms. Studies are still in progress in an effort to determine the factors involved governing the occurrence of this disease in the wild.

In the study of blood protozoan parasites we have obtained a vast amount of material. Blood smears have been procured from several thousand individual quail, mostly trapped birds primarily collected as part of other studies on this species. These data have been supplemented by studies on captive quail at the various state game farms and experiments at the laboratory. The earlier work of O'Roke indicated that the louse fly *Lynchia hirsuta* is a possible vector and subsequently we have implicated the large louse fly *Stilbometopa impressa* as a carrier of the *Haemoproteus*-malaria parasite. Very little of our data on this project have reached publication pending clarification of several new forms found and further statistical analysis of the information on hand. Various phases of this study are still in progress and the program has been expanded in some directions in an effort to clarify data obtained in the earlier stages of our surveys and experiments.

No work has been done on botulism in the past few years because of its diminished occurrence in most of California. The chief area where losses have occurred in past years, Tulare Lake, has presented no problem since the main body of water has been dried up.

Studies on fowl cholera have become our main concern in our investigations of waterfowl disease. Potentially losses may become severe enough to decimate seriously our present waterfowl population. Our chief efforts are an attempt to determine the source of this infection and the mechanisms by which it is carried from one area to another or from one year to the next and from this data to develop such control measures as may be feasible.

Extensive work has been completed on studies of various diseases and parasites of deer. The main problems confronting us now are to determine methods of combatting stomach worm infections and various other diseases that occur in these animals. During the recent dry years so-called foot rot—infections involving the organism *Spherophorus necrophorus*—has been the most evident disease and has taken a heavy toll in several areas. Now, with the advent of a wet winter, stomach worms and other parasites have become predominant and are causing losses, particularly in younger deer.

An extensive project is in progress to determine the blood picture of deer, including blood chemistry, in the expectation of finding reliable factors that can be used as an indicator of the animal's condition. It is anticipated that the results of this study will give us a base that can be used as an index of the state of nutrition of the deer as it relates to range management, and incidentally classify the anemias that may occur in these animals.

Perhaps the greatest progress has been made in our efforts at the state-owned game farms. Pullorum disease (a bacterial disease of the intestinal tract of gallinaceous birds known as bacillary white diarrhea) is the number one problem of the domestic poultry of the State, and the California Department of Agriculture and poultry industry are making extensive efforts to keep this disease under control. Evidence of the infection in game farm pheasants led us to undertake a control program. Our results indicate that this disease has been eradicated from all our game farm units and constant check is being made to keep birds free of this infection.

In recent years avian type tuberculosis probably was among the greatest causes of deaths occurring in adult pheasants and chukars at one of the game farm units. Management procedures employed to combat this disease have apparently practically eliminated the infection and cases of tuberculosis are now rare.

Experiments on the control of gapeworm infections in the game farm birds are being attempted at the present time but have not progressed sufficiently as yet to justify an analysis of the applied measures. Studies are also in progress on so-called quail disease, ulcerative enteritis, which takes a heavy toll of the game farm quail.

Various other projects have been undertaken or are in progress but these either have not progressed sufficiently or are of a minor nature and do not warrant detailed mention in this review.

SURVEYS AND DIAGNOSIS

One of the chief projects of the laboratory staff is the collection of survey data to determine what parasites and diseases occur in our wildlife, the incidence, prevalence and distribution of these infections in the wild and their relative importance. It also is necessary to act as a service unit in the diagnosis of losses which may occur from disease. These two phases of our work are coordinated so that specimens obtained for diagnosis serve as the chief source of the material for survey data. This is frequently supplemented by special studies, such as examination of hunter-killed specimens and examination of specially trapped animals. The findings under this procedure serve as the governing basis by which the special research problems requiring investigation are determined. The main success of this program depends on the cooperation of field personnel, particularly the patrol force who are constantly in the field and in the best position to observe the problems as they arise. Members of the field staff of the Bureau of Game Conservation also play a role in this phase of our work and the men working on management programs and predatory animal control have proved very helpful, particularly where further specific data are needed to clarify a diagnosis or to obtain sufficient survey material to present valid statistical information.

The procedure for handling such material varies considerably according to circumstance. It is sometimes necessary to travel into the field to collect sick specimens. At such times having an experienced hunter and trapper assigned to our staff is of tremendous aid. The cooperation of members of the patrol force is extremely helpful at these times.

Frequently freshly dead specimens come into the possession of wardens and require examination at the laboratory. These may be brought into the laboratory or members of the laboratory staff may go into the field to procure them.

In cases where specimens are to be shipped to the laboratory the method of handling may be very important. The specimens may be packed in borax powder, frozen in dry ice, preserved in formalin or some other technique may be employed. The efficacy of any preserving method depends on the use to which the laboratory must put the material in order to make a diagnosis. No hard and fast rules of procedure can be recommended for field personnel to follow in every case. It seems best at present to advise the field personnel to contact the laboratory without

delay when specimens come to hand so that they may be informed of the best method of handling. In cases where special material is to be collected for a specific purpose previous discussion with a member of the laboratory staff is usually sufficient to determine methods of handling.

As far as possible with existing staff and facilities diagnosis is determined at the Berkeley laboratory of the bureau. On occasion, where necessary, other agencies cooperate either by making a specific diagnosis or by confirming our own findings. Frequently other agencies and institutions in various parts of the State have cooperated by making their facilities available to us when working in their area. With our mobile laboratory this procedure is no longer as necessary as in the past.

The special mobile laboratory of the division is a valuable adjunct to the Berkeley laboratory. This vehicle was designed to fill the need for rapid diagnosis of wildlife disease in the field. The emphasis was placed on mobility and maneuverability so that the site of a disease outbreak

FIGURE 48. The mobile laboratory. *Photo by Kramer Adams.*

could be reached quickly even in areas that might be considered somewhat inaccessible. It also was considered important that it contain all of the necessary facilities for complete diagnosis in the fields of bacteriology and parasitology so that it would be a completely self-sustained laboratory. Since this is a new type of equipment for the study of wildlife disease a description of the unit is given.

The mobile laboratory is based on a one-ton panel truck. (Fig. 48). The vehicle has four speeds forward including a compound low gear. The generator has been replaced by an alternator that produces 80 amperes

for charging three storage batteries. One of the storage batteries is used in the normal manner, while the other two in series provide 12 volts. The current produced runs an inverter which supplies a 110-volt alternating current, providing power for three fluorescent lamps, an air conditioning fan, a centrifuge and for other uses that may occur.

A five-gallon butane tank is mounted on a plywood partition behind the driver's seat. This supplies fuel for the bunsen burner and gas may also be used as a source of heat when outside temperatures make it necessary and to prevent the breakage of bottles containing reagent solutions that might freeze.

Mounted from the ceiling directly behind the driver's seat is a 30-gallon water tank filled from the outside. This water supplies the sink and the air conditioning unit. A refrigeration box is directly behind the driver's seat with a metal lined box and insulated with glass wool. Ordinary ice or CO_2 dry ice may be used as the refrigerant.

FIGURE 49. View of interior of the mobile laboratory. *Photo by Kramer Adams.*

The inside of the truck provides the working space for laboratory procedures (Fig. 49). Cabinets and drawers are installed on the partition. Reagent bottles and glassware are fitted into rubber lined slots mounted in a shelf that slides out for convenience. A compartment was constructed that holds the microscope in its case for double protection. Two folding tables and the sinkboard provide workspace. Eighteen-inch library-type steel stools with rollers give adequate working space, and allow two workers to move about the quarters that otherwise would be cramped. Windows were cut through the panel side above the folding tables to

provide adequate light, and the interior is painted white to insure maximum use of natural light. Two swinging brackets mounted above the rear doors provide for suspension of deer or other large mammals for ease of performing a necropsy. An aluminum table with an adjustable leg is hinged to the floor at the rear entrance so that the internal organs can be examined outside, or where birds or small mammals can be autopsied.

This vehicle has proven invaluable in the rapid diagnosis of disease at locations away from the headquarters laboratory. In addition to its usefulness in providing a means of quickly determining the cause of a disease and thereby allowing all preventive and control measures to be initiated with greater dispatch, this mobile laboratory has been used in extending research on particular diseases to the field environment where they occur.

The main concern of the laboratory is the study of parasites and diseases of game species of mammals and birds. Since many of the infections also involve other species of animals, it is often necessary to investigate the infections of non game species in order to obtain the complete picture of epidemiological relationships. An effort is made to confine our research for the most part to specific problems that will yield data necessary to anticipate or ultimately instigate control measures. However, it is usually necessary to have at hand much academic information which is basic to any further study. As much as possible academic problems that lend themselves to such procedure are farmed out to qualified graduate students or other individuals whose personal interests tie in with material we have on hand or can obtain easily. Further, when studies are completed on material which would be of teaching value, such specimens are presented as gifts to various colleges to be used for classroom or research study.

On many occasions various members of the faculty of the University of California, other institutions, and personnel of the Departments of Agriculture and Public Health have cooperated or collaborated with us on some of our problems which have interests in common. Several joint research and survey projects have also been undertaken.

The study of diseases of wild life is still very much in its infancy. Often much more time is required to obtain a diagnosis or the answers to many of the problems than the results might seem to warrant. Efforts to obtain a diagnosis of losses occurring in the field frequently seriously interrupt the research projects necessary to obtain the basic data which are imperative before any progress toward control can be anticipated. As our knowledge advances it will become even more necessary that the assistance of collaborating individuals and institutions be procured if the information on the basic academic phases of our problems is to be available and keep pace with our efforts to solve the ultimate purpose of our existence—the control of wild-life diseases.

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NOTES

LARGE DOVER SOLE TAKEN OFF EUREKA

On September 21, 1948, the otter trawler *St. Patrick*, captained by Earl McCarty of Eureka, obtained a catch of very large Dover sole, *Microstomus pacificus*. Several fish ranged from 7.5 to 10.3 pounds in total weight. Total lengths of these large fish varied from 646 mm. to 710 mm., a range of 25.43 to 27.95 inches. All were taken in the same drag, at a depth of 100 fathoms, northwest of Humboldt Bay bar. The maximum length previously given for this species was 24 inches. The largest specimen obtained was a female with ovaries large, distended and granular. The ova were approaching the translucent condition that occurs prior to spawning. Ovum diameters ranged from 1.0 mm. to 1.2 mm. Measurements on this fish were: 710 mm., or 27.95 inches, measured from the tip of the snout to the longest caudal ray; standard length 615 mm., 24.2 inches; depth of the body 342 mm., or 13.47 inches; round weight 10.30 pounds. Scales taken from this individual indicated an age between 18 and 20 years.—*Frederick B. Hagerman, Bureau of Marine Fisheries, California Division of Fish and Game, April, 1949.*

REVIEWS

Trout Fisheries in New Zealand, Their Development and Management

By Derisley F. Hobbs, New Zealand Marine Department, Wellington, New Zealand, Fisheries Bulletin Number 9, 1948, 175 pp., 31 plates, 25 tables, appendix 5.

This book will be welcomed by all who are working on trout fishery management problems.

Mr. Hobbs has covered his subject well. He has set down in a clear manner a review of the development of trout fishing in New Zealand from the time of introduction of the first trout into the country, about 1865, until the present time. He describes the part played by trout hatcheries, which were established at the time of the first shipment of eggs into the country. The primary function of hatcheries then was to receive trout from other countries in the only stages they could be safely transported at the time, namely eyed eggs. Later the hatcheries were used in an attempt to maintain the fishery at a high level. The author questions their value as an important adjunct to natural reproduction. In his discussion relating to the efficiency of natural reproduction versus hatchery production he calls attention to the "unconcious propaganda of numbers." "The number of eggs handled in hatcheries sound impressive and look impressive on paper until they are viewed in relation to the number of fish which produce them or the number of eggs not handled in hatcheries." Some of the author's general conclusions about hatcheries in New Zealand are: "the losses resulting from interference with natural spawning runs and the artificial propagation of eggs obtained have usually been greater than would have occurred had fish been left to spawn naturally" and, "it is desirable to seek more beneficial ways of spending approximately 70 percent of the funds available for development and maintenance of stocks."

Several interesting illustrations in the book add emphasis to the text. The pictures of streams and lake types are of interest for comparison with streams and lakes in California coastal and valley districts.

The book is divided into four parts: Part I—Historical; Part II—Recent management of fisheries in New Zealand; Part III—Recent investigational work on fisheries management in other countries; Part IV—Future management and development of fisheries.

As the author points out, much data are lacking to warrant certain conclusions. He has, however, made use of all available information. Among other things he shows that the production of streams of New Zealand in terms of pounds of trout produced is as great today as it was when the fishery first began over seventy years ago.

His careful analysis of data at hand is worthy of imitation. Those persons interested in trout fishery management will find "Trout Fisheries in New Zealand" of decided interest and a definite help in the solution of their own problems.—*Harry A. Hanson, California Division of Fish and Game.*

Trapping

By Harold McCracken and Harry Van Cleve. A. S. Barnes Company, New York, 1947, 196 pp., $2.75.

This is a small but comprehensive volume dealing with life history, habits and range of the different furbearing animals of North America and methods of their capture. It should prove to be a valuable reference, especially for beginners, and perhaps many trappers who have not thoroughly learned the art of trapsetting. However as pointed out by the authors "Whether you are trapping amid the snow and ice of Alaska or the marshlands of Louisiana the most important requirement for successful trapping is to have a thorough knowledge of the animal sought. The trapper must be a naturalist as well as an expert in the art of setting traps. The printed page can only be an elementary guide and real knowledge comes only from first hand experience."

The authors apparently consider the fox to be one of the most difficult to trap inasmuch as they seem to stress the fact that in order to catch him the traps should be free from all oil, grease and human or domestic odors. In order to accomplish this the traps should be boiled in a solution made by boiling the bark from different trees, branches from shrubs or black walnut hulls. Foxes in the northern country and perhaps in the east may be hard to catch but in California our predatory animal trappers have difficulty in keeping a fox out of their traps. However it is heartily agreed that traps should be kept clean and free from all odor if the trapper

expects to attain a maximum of success. This especially applies to traps used for trapping the coyote.

Under the heading of "Wolf Blood" the authors tell of the advisibility of having wolf blood in the different breeds of sled dogs, the reason being that the work of a sled dog is mighty tough and there are exceedingly few breeds of dog that can stand it. Their feet are usually the first part to give out. I agree on all this but they then go on to tell us that the reason the dogs feet give out is because icicles have a habit of forming on the long hairs between the eyes causing him to go lame. No doubt this is a misprint but if not it is a new one on me. I never would have thought to look for icicles between a dog's eyes to locate the cause for lameness. Or should I?

Anyhow it is a good little book and is well worth the price to any young man who intends spending even part of his time at the business of trapping. From cover to cover it is interesting and contains much valuable information including hints and kinks for the outdoorsman.—*J. R. Wallace, California Division of Fish and Game.*

The Ruffed Grouse

By Frank C. Edminster. New York, The Macmillan Company, 1947, 385 plus xxvi pp., 28 line cuts, 157 photographs, $5.

The author has made available to ornithologists and game managers a wealth of information concerning this popular game bird. One must marvel in the adaptability of this species for this elusive and wary bird (during hunting season) was commonly called "fool hen" not many years ago. It's amazing and complex courtship activities are well known and the cause or causes of periodic population fluctuation has been a point of argumentation among orinthologists for several decades. The author has summarized all of the proposed theories affecting periodic fluctuations and states that, "These fluctuations are not sufficiently regular to be caused directly by some all-pervading common cause. They are inconsistent geographically, both in time of occurrence and severity of action." He completes this discourse with a statement that there is still much to learn about the subject.

Life history, ecology, and applied management are well covered in a text which is usable to a high degree. The author had seven years of experience in working with this species while serving with the New York State Conservation Department, and nine years of subsequent wildlife work with the U. S. Soil Conservation Service which has greatly broadened the scope of his research. References are liberally cited and an excellent detailed bibliography accompanies the text. The illustrations are excellent but it is felt that they should have been used throughout the text where applicable rather than being concentrated in one section.

The final chapter, "Management of the Ruffed Grouse," is logical in its presentation and should prove of value to game managers working with this species. This should be a basic text for reference work for many years.—*Henry A. Hjersman, California Division of Fish and Game.*

The Ruffed Grouse

By Henry Marion Hall; illustrated by Ralph Ray. New York, Oxford University Press, 1946. 91 pp., 8 col. pls., 10 figs. $6.50.

This companion book to "Woodcock Ways," by the same author, is well bound but the colored plates lack in authenticity. The text is of narrative style which makes for ease of reading, despite the wealth of information contained. Although Mr. Hall describes management practices in regard to this species, the book is intended for the sportsman and casual reader rather than the game manager or biologist. He does cover the gunning of ruffed grouse quite thoroughly especially in regard to guessing the direction of flight, forcing the flight, and conditions under which fast shooting is required.

This is recommended reading for the sportsman but interesting to anyone who enjoys days in the woods.—*Henry A. Hjersman, California Division of Fish and Game.*

Big Game Hunting

By Elmer Keith; illustrations by Bob Kuhn and author. Boston, Little, Brown and Company, 1948, 420 pp., photographs, $7.50.

Keith's lifetime experience as a big game hunter, guide and outfitter made it possible for him to test his many theories concerning rifles and loads. His writings of these experiences and his hunting methods make entertaining reading for all interested in big game hunting.

The book is well arranged and indexed. There is a separate chapter on the hunting of each of the big game mammals of North America.

The opening chapter titled, "How to Look for Game," is an original and well presented thesis on an important but seldom discussed part of big game hunting.

The author assumes that the hunter will be guided and outfitted by professionals. The chapter on "Pack Outfits and Tentage" and "Equipment" are written with this viewpoint reducing its value to independent hunters.

Keith has very definite opinions on the efficiency of various rifles for big game hunting. He reports on the performance of a number of "wildcat" and foreign rifles but neglects some of the most popular rifles of commercial United States manufacture.

Deer are not given a place in this book commensurate with the number of sportsmen that hunt deer as their only big game.—*James D. Stokes, California Division of Fish and Game.*

Shots at Whitetails

By Lawrence R. Koller, drawings by Bob Kuhn. Boston, Little, Brown and Company, 1948, 359 + vii pp., photographs, illus. and index, $5.

Koller is evidently well qualified to write on the subject of whitetail deer hunting. Although the title would indicate that this book is composed of a number of hunting anecdotes, this is not the case. The book covers the sport of whitetail hunting in detail, from the first chapter on the whitetail's natural history through hunting methods, choice of weapons and loads, preparation of meat for the table to mounting of the trophy head.

Outstanding is the author's inclusion of advice to the beginner, the unattached city hunter, and hunter of moderate means, as well as to the club and private reserve hunters.

The methods of hunting described have been used successfully by the author. He has steered clear of the common superstitions of the so-called "old-timer."

While this book covers very thoroughly its subject, it must be remembered that it deals with one species of deer, the whitetail, and one section of North America, New York State. Thus many of the hunting methods and the method of handling and aging the venison cannot be used in the West.—*James D. Stokes, California Division of Fish and Game.*

Wildlife Management: Upland Game and General Principles

By Reuben Edwin Trippensee, McGraw-Hill Book Co., New York, 1948, x + 479 pp., 36 figs., 71 tables. $5.

There is a growing demand for classroom texts summarizing the diverse and scattered recent literature in the wildlife field. Trippensee's *Wildlife Management* is a step toward filling this need.

The first 24 chapters are arranged in three main parts—Farm, Forest and Wilderness Wildlife. Each part is introduced by a chapter on general considerations in management, followed by detailed discussion of individual species or groups of related species. The remaining seven chapters of the book (there are 31 in all) cover Miscellaneous Wildlife Relationships and Wildlife Administration. Fur-bearers and waterfowl are not treated in this book, but they will be the subject of a companion volume to be issued later.

The book has real value to a beginning wildlife student in assembling for convenient reference a considerable volume of information about several dozen important game species. Some of the compilations are well done, particularly those concerning eastern species on which the author himself has worked, as for example the cottontail. Food habits of many species are treated exhaustively, and most essential facts of life history, ecology and management are included. The value of the book is such that it has been adopted by the reviewer as the beginning text in wildlife management at the University of California.

At the same time there is much to criticize in the volume. Many important western species are only sketchily covered. Frequently data are offered with little critical analysis or synthesis. Numerous important papers that appeared after 1940 are completely overlooked, and the whole point of view is rather that of the "food patch" era of game management which characterized the 1930's. Ideas of the last decade on population phenomena (sex and age composition, turnover and productivity rates, etc.) are scarcely acknowledged. A chapter on disease (by E. C. O'Roke) mentions only in passing the ecological aspects of disease in wild populations but devotes pages to the symptoms and cures of game farm maladies—hardly an up-to-date treatment.

Some of the range maps are grossly inaccurate. Pheasants in California, for example, are shown in the extreme northern counties and their presence is not acknowledged in the Central Valley (where the 1948 kill probably exceeded half a million birds). Gambel quail are shown over all of Southern California including the coast from Santa Barbara to San Diego. Two large blocks of bobwhite range are indicated in Northern California. And so on. All of the maps were taken from other publications, but this does not absolve Trippensee from his responsibility for reasonable accuracy, particularly when distribution data can be obtained with very little effort.

With all its shortcomings, *Wildlife Management* will serve a good purpose as a general reference book for wildlife beginners, though it is not of a caliber to become a classic in the technical literature.—*A. Starker Leopold, Museum of Vertebrate Zoology, University of California.*

Know Your Ducks and Geese

By Angus H. Shortt and B. W. Cartwright. Sports Afield Publ. Co., Minneapolis, 1948, $5.

This is the Sports Afield collection of know your ducks and geese. This series started to run in *Sports Afield Magazine* in January, 1946. One species appeared each month through three full years. The editors of the magazine have brought together all of these excellent paintings into one volume, beautifully bound, pages 11¾ inches by 14 inches. Thirty-six species of waterfowl are treated, a full page painting of each is presented preceded by a tissue sheet giving pertinent data on the species. The color pictures show the ducks in full nuptial plumage. The text on the tissue sheets carries black and white sketches of the birds on the water and a map showing the known distribution in North America.

This edition is dedicated to waterfowlers everywhere. It would make an excellent addition to the library of every student of waterfowl as well as sportsmen. The editors of *Sports Afield* Magazine are to be commended for making this excellent collection available to the public at such low cost.—*Carlton M. Herman, California Division of Fish and Game.*

REPORTS

SEIZURES OF FISH AND GAME

January, February, March, 1949

Fish:	
Abalone	1,165
Crabs	43
B. Bass	53
Bass	25
Catfish	16
Steelhead	11
Clams	2,500
Cockles	7,511
Lobsters	135
Lobsters, pounds	213
Salmon	2
Mullet	5
Sunfish	58
Skipjack, pounds	3,747
Sardines, pounds	128,500
Game:	
Coots	4
Deer	28
Deer meat, pounds	366
Doves	4
Ducks	895
Geese	34
Grouse	2
Shorebirds	4
Pheasants	47
Nongame	70
Pigeons	56
Squirrels	3
Quail	24
Rabbits	29
Swans	24
Sea Otter skins	2
Beaver skins	4
Muskrat skins	38
Mink skins	4

FISH CASES

January, February, March, 1949

Offense	Number arrests	Fines	Jail sentences (days)
Abalone: Overlimit; undersize; out of shell; closed season	87	$2,160 00	34
Angling: Closed stream; set lines; at night; possession gaff 300′ of stream	176	2,273 00	52½
Chum: Salmon eggs	1	50 00	
Mullet: Illegal nets	3	250 00	
Bass: Undersize; overlimit; at night; 2 rods	29	568 00	
Crabs: Undersize	3	75 00	
Clams: Undersize; overlimit	165	3,817 00	
Commercial: Round haul, dist. 20; no party boat license; resist arrest; illegal gill nets	37	1,360 00	15
Pollution: Oil; fish refuse	12	1,000 00	
Salmon: Snagging; gaffing; spawning beds	4	200 00	
Trout: Closed season	6	25 00	
Cockles: Overlimit; undersize	28	670 00	
Licenses: Transfer; back dating; false statement	8	115 00	
Sardines: Undersize	7	100 00	
Lobsters: Undersize; traps in closed district	13	1,085 00	
Catfish: Fyke nets	7	288 00	
Skipjack: Undersize	1	150 00	
Steelhead: Closed season; other than hook and line	2	250 00	
Sunfish: Overlimit	1	25 00	
Totals	589	$14,461 00	101½

Court Forfeitures

Undersize mackerel and sardines	$11,001 39

GAME CASES

January, February, March, 1949

Offense	Number arrests	Fines	Jail sentences (days)
Coots: Closed season	2		3
Deer: Doe; spike buck; taking in refuge; no tag; spotlighting	67	$6,146 00	262
Deer meat: Closed season; unstamped	28	3,400 00	350
Doves: Closed season; illegal import	3	105 00	
Squirrels: Closed season	4	200 00	
Ducks: Offer for sale; purchase; closed season	252	13,150 00	50
Geese: Closed season; overlimit	13	415 00	
Pheasant: Hen	28	2,475 00	74
Nongame: Possession	17	512 00	
Grouse: Possession	2	275 00	
Pigeons: Closed season	16	580 00	
Quail: Closed season	5	90 00	
Rabbits: Closed season	37	1,021 00	10
Shorebirds: Killing	4	85 00	
Swans: Possession	22	1,400 00	
Hunting: Unplugged gun; from highway; powerboat	270	6,605 00	
Sea otter: Skins, possession	1	100 00	
Beaver and Mink: Hides, illegal possession	1		
Totals	772	$36,559 00	772

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CALIFORNIA STRIPED BASS CATCH RECORDS FROM THE PARTY BOAT FISHERY: 1938-1948[1]

By A. J. Calhoun[2]
Bureau of Fish Conservation
California Division of Fish and Game

The increase of striped bass (*Roccus saxatilis*) in California after their introduction in 1879 captivates the imagination. The original nucleus of a few hundred fingerlings mushroomed in 20 years into a population yielding a million pounds of fish a year. Since then abundance has continued at a high level, and the species has become a natural resource of considerable value.

There can be little doubt that the striped bass fluctuate in abundance from time to time in California, and the desirability of measuring and understanding the fluctuations which occur is fairly obvious. Good catch records are particularly helpful in this connection. Fortunately, a large backlog of party boat[3] records was on hand when the present striped bass investigation was begun in 1946. They were surprisingly complete and informative, considering the difficulties usually encountered in getting good angling catch records on a large scale. Nothing had ever been done with them beyond maintaining the system of reporting, largely because of personnel shortages during the war. The formidable task of developing a meaningful picture from more than 30,000 of these records, covering 11 consecutive years, has now been finished, and it is the purpose of this report to summarize the results. They provide a good resume of happenings in the fishery since 1938.

Other types of striped bass catch records are also of interest, particularly those obtained from postal card surveys of California angling catches. However, they will be mentioned only very briefly in this report. Some attention is also given to the old commercial catch records, which demonstrate the relative stability of the fishery over a long period of years.

GENERAL DISCUSSION OF PARTY BOAT RECORDS

Description of the Party Boat Fishery

The California striped bass fishery is largely restricted to the waters within the Golden Gate. From time to time there is a run of fish in the surf along the ocean beaches north and south of San Francisco, but generally speaking, this part of the fishery is of minor importance. Party boat fishing for bass is confined to the lower sections of the Sacramento-San Joaquin river system, shown in Figure 50. Fishing changes seasonally in the different fishing areas, following a fairly regular pattern. The main shifts in activity occur up the river into brackish and fresh

[1] Submitted for publication July, 1949.
[2] The assistance of Chester Woodhull, William Johnson and Harry Kennedy in sorting and tabulating records is gratefully acknowledged.
[3] Boats taking parties of anglers out fishing, usually for a fixed charge per passenger.

water during the autumn and back down into the bays again in the spring. Some boats migrate with the fishing, while others remain inactive in their home waters during the off-season there.

FIGURE 50—Orientation map of the California striped bass fishing region. The numbers indicate the fishing blocks referred to in the text

The fishing "blocks" shown in Figure 50 are a modification of a system set up by the Bureau of Marine Fisheries of the California Division of Fish and Game. The various boundaries are the obvious ones except in the case of Block 308, shown in greater detail in Figure 53. This block is fished mainly by boats working out of harbors in or near the Carquinez Straits. The original arrangement, in which all of San Pablo Bay was one block, and the Carquinez Straits and Suisun Bay together were another, proved to be unsatisfactory because two blocks were frequently represented in a single trip when it was used. This confused the handling and the interpretation of the records, so the change shown in Figure 50 was made.

Striped bass angling methods are highly standardized and suprisingly uniform. There are only two types of any importance: bait fishing with pieces of sardine and trolling with artificial lures. The bait fishery is the more important of the two. The vessels in the party boat fleet vary all the way from the smallest of inboard cruisers to large and fairly elaborate vessels specially outfitted for the fishery. Small craft of every sort have been adapted for use as party boats, as would be expected. All-day trips are the general rule. However, two or three boats usually operate on a half-day basis except during the winter. The skippers vary greatly in the amount of fishing which they do, ranging from almost

TABLE 1

Composition of the Striped Bass Party Boat Fleet in 1947

Type of operator	Number of operators *	Average number of days of operation during the year
Professional, main source of income	31	105
Nonprofessional, but with some degree of permanence of operation	11	38
Others	56	16

* Some nonreporting operators are included in these totals on the basis of other information about their activities.

continuous to highly sporadic operation. Table 1 outlines the composition of the fleet in 1947. It pertains only to striped bass fishing. Some of these same operators also take parties salmon fishing outside the Golden Gate.

The System of Reporting

The present program of party boat reporting of striped bass catches was started in the late 1930's, when it became necessary to find a substitute for commercial catch records.[1] H. B. Nidever, G. H. Clark, and R. S. Croker of the Bureau of Marine Fisheries organized the program.

The Bureau of Patrol also deserves recognition for the work it has done in maintaining a high level of reporting, and a great deal of the credit for the excellent series of records which have been obtained since 1938 must go to the wardens on marine patrol.

The party boat operators are required by California law to keep accurate records of each day's catch and to submit monthly reports. Their cooperation has been noteworthy, and we are particularly grateful to the many individuals who have kept conscientious records even during periods when little or no pressure was placed on them to do so.

Evaluation of Party Boat Records

Party boat records have certain unique advantages. Foremost is the high level of accurate reporting attainable with a minimum of well-directed attention. This contrasts sharply with the rest of the fishery, for which useable records are most difficult to obtain. The party boat records are easy for the operator to keep because only one species is ordinarily involved and because it is of interest and importance to him personally to determine the two basic facts in which we are also most interested, namely, the number of anglers fishing and the number of fish caught.

In contrast, extensive efforts to obtain records from boat-rental establishments have shown that it is impossible to obtain satisfactory records because the operators are too busy handling the boats to be able to record the things we would like to know.

A second important advantage of the party boat records arises from the excellence of the party boat fleet as a device for measuring the abundance of striped bass. The sources of fishing information are fairly well organized and considerable scouting goes on over wide areas, with the result that good coverage of the fishing grounds is generally obtained.

[1] On August 14, 1931, it became unlawful in California to catch striped bass with nets except when taken accidentally in shad nets.

Again, this is in sharp contrast to the skiff fishery, which tends to concentrate in the immediate vicinity of the boat liveries and to reflect the abundance of fish in localized areas. Local changes in the abundance of striped bass are as abrupt and extreme as they are irregular, and they are meaningful only in relation to the over-all picture.

A final advantage of the party boat records, and one of the most valuable, is the high degree of continuity in the party boat fishery and in the actual records themselves. This continuity enables us to detect fairly readily long-range trends and seasonal and regional changes in fishing quality.

There are several gaps in the picture of the striped bass fishery provided by the party boat records. These include the spring season in the rivers above the Delta, the run which occurs from time to time along the ocean beaches north and south of the Golden Gate, a fairly important fishery in the Napa River, and the scattered summer fishing for small fish in and above the Delta. With these exceptions, good fishing usually attracts the nearest components of the fleet at once and is reflected in the records accordingly. Prolonged periods of good fishing in one area cause boats to move in from other areas.

The accuracy with which the operators report is believed to be high. Attempts at evaluation have confirmed this belief, although failure on the part of some operators to send in reports for all the days fished each month has been detected in some instances. However, this should not alter the picture greatly. There can be no doubt that periods of very good fishing and periods of very poor fishing are revealed clearly by the records, and it is reasonable to expect intermediate conditions to be shown with comparable clarity.

While on the subject of the validity of these records, it is interesting to note that in one rather extensive comparison average weights of fish reported by party boat operators were surprisingly similar to those obtained from creel checks of anglers who had been fishing in the same restricted area.

Party Boat Fishing Effort

Party boat fishing probably represents less than 10 percent of all striped bass fishing in California. It is not yet possible to estimate its relative importance with any assurance. About 5,000 individual party boat trips were made in 1947 and about 4,000 in 1948. These estimates are outlined in Table 2. Errors present will tend to make them smaller

TABLE 2

Estimated Total Days of Party Boat Fishing for Striped Bass

Year	Reported party boat days *	Estimated percent reported	Minimal estimate of total days
1947	4,215	83	5,077
1948	3,537	86.8	4,075

* Includes reports of half-day boats by days of operation rather than by numbers of trips.

than the true figures. It must be emphasized that special effort was made to get the best possible estimates, and even though they are not completely accurate they are of considerable value. Records of this sort, which depend on the truthfulness and integrity of many individuals, are quite difficult to verify. The level of reporting is probably not as high as column three of Table 2 would indicate. This column is based on a survey in which all the permittees who failed to report completely were asked about their fishing activities at the end of the year. Some of them undoubtedly failed to record all trips.

A slump in striped bass fishing occurred during the war, judging from the available evidence. Estimates furnished by individuals in close contact with the fishery at that time indicate a decline during the war of about a fourth to a third of the pre-war volume of fishing. Decreased reporting during the war, shown in column two of Table 3, indicates a

TABLE 3

Summary of Reported Party Boat Fishing Effort

Year	Boat days*	Angler days	Anglers per boat day
1938	1,984	10,377	5.2
1939	2,834	15,108	5.3
1940	3,925	19,924	5.1
1941	3,969	21,496	5.4
1942	1,629	8,739	5.4
1943	1,361	8,884	6.5
1944	860	5,228	6.1
1945	1,869	11,354	6.1
1946	2,736	14,481	5.3
1947	*3,487	19,226	5.5
1948	*3,053	15,338	5.0
Totals	27,707	150,155	5.4

* Half-day records not included, hence the discrepancy when compared with Table 2.

real contraction in party boat fishing. However, part of the decrease in reporting undoubtedly resulted from the fact that little attention could be given to the program during the war and some of the less cooperative operators stopped sending in records. The matter is brought up here because of the effect it had in reducing the numbers of reports received and increasing the numbers of inadequate samples during the war years.

Method of Handling Party Boat Records

The log sheet used by party boat operators, shown in Figure 51, has remained essentially the same during the period covered by this report.[1] These forms are supplied by the California Division of Fish and Game.

The first step in dealing with the thousands of accumulated daily logs was to sort them by year, month, and fishing block. Next, they were grouped into units consisting of all those for one fishing block for a single month. This procedure was based on a considerable amount of preliminary work. Units of less than 30 logs were considered inadequate for deriving monthly averages of daily catches, and they were not used for that reason. Generally, when less than 30 logs are received from a block during a month, fishing is either very poor or weather is unsuitable for

[1] Minor unimportant changes were made in 1948.

*Daily Log of Boat*_____ F. & G. No._____ Place of Landing_____ Date___/___/___ (Month / Day / Year)

Leave_____ M. Started fishing_____ M. Finished fishing_____ M. Return_____ M.

Areas fished (Port or Anchorage)_____ Block No._____ Number in party fishing_____

(Local Name of Place)

KIND OF FISH CAUGHT	Number of Fish	Total Weight

Weather_____ Tide_____

Condition of water_____

Kind of Bait or Lure used_____

REMARKS:

[SIGNED]_____

SERIAL Nº 107964

FIGURE 51—Daily log form upon which party boat operators report catches of striped bass

angling. Good fishing attracts the boats in numbers and large samples usually result, especially in Blocks 301, 308 and 303. The minimum sample for use in deriving average weights of striped bass caught was set at 200 fish, irrespective of the number of daily trips involved.

The angler day is the standard unit of fishing effort used in all of our striped bass work. Catch per angler per hour, often used in other sport fisheries, is unsuitable because striped bass commonly bite most actively during brief periods at certain stages of the tide. As a result, an hour of fishing at one time during the day may be more productive than the four or five preceding or following hours.

Some of our best reports have been obtained from boats operating on a half-day schedule, and this has complicated matters. A comparison of the relative success of half-day as compared with whole-day trips, shown in Figure 52, indicates a fairly stable relationship between the two, and they can therefore be safely combined. Each point in the scatter diagram in Figure 52 is based on 30 or more trips of each type in one block during a single month. Records from Block 308 predominate, but others are also included. No difference in the blocks was apparent in this connection. The trend was drawn in "by eye." The procedure adopted for combining the two types of records has been to derive the average catch for each separately, then to adjust the half-day sample on the basis of the curve in Figure 52, and finally to average the two, each being weighted according to the number of trips involved. In the present report half-day reports have been used only in four monthly samples for Block 308 and four for 301, which otherwise would have been inadequate. They will be used routinely in the future.

The same form of presentation has been used throughout this report to facilitate comparisons. Separate sections deal with each fishing block, and in each case the basic data are plotted in a pair of checker diagrams. One of these shows the average catch per angler day and the other shows the average weight of the striped bass caught. A given square always represents the same month of the same year in any diagram.

It had been hoped at the outset that it would be possible to derive a single figure which would represent striped bass abundance for a given

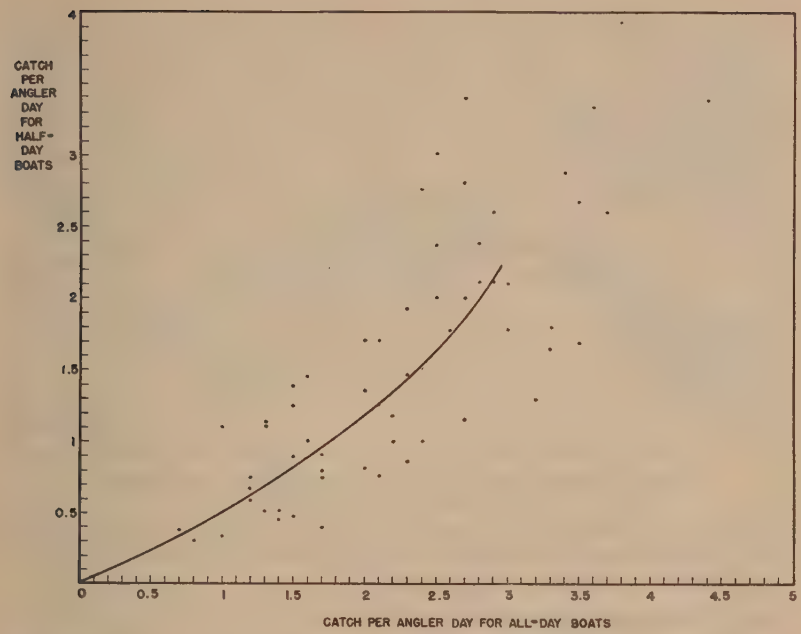

FIGURE 52—Scatter diagram showing relationship between average catch per angler on half-day and whole-day trips

year satisfactorily, comparable with those in previous reports on the commercial catch (Craig 1930, Clark 1933). This idea was finally given up in the belief that it would be an over-simplification which could easily lead to misinterpretation. However, an annual estimate which is of some interest is discussed in a final section of the report.

RECORDS FROM BLOCK 308—THE CARQUINEZ STRAITS REGION

Description of Fishing Block 308

This block, shown in Figure 53, includes the Carquinez Straits and immediately adjacent parts of San Pablo Bay and Suisun Bay. It is primarily a deep-water, channel region, as can be seen from Figure 53, in which depths under 10 feet are shaded. Salinity fluctuates from almost that of salt water in the autumn in dry years to nearly fresh in the spring in wet years.

Most of the grounds usually fished by party boats moored at Crockett and Martinez, two of the most important centers of activity, lie within Block 308. The Napa River is also included, but it is unimportant in the party boat fishery except at its mouth. The waters surrounding the mouth of the Napa River, the channel area off Rodeo, the deep water off Port Costa and the sand bar off Avon are favored fishing spots for the party boats. Bait fishing predominates in this area, as elsewhere, but trolling is also important. However, the latter is largely restricted to the summer months, and even then it is carried on for only a few hours before sunset. Hundreds of boats are often to be seen trolling the Carquinez Straits on late summer afternoons, and they make a picturesque flotilla, ranging

FIGURE 53—Map of Block 308. Broken lines indicate its boundaries. Shaded areas are shallow water

all the way from 60-foot yachts to skiffs with outboard motors. Party boat operators have necessarily become masters of the art of trolling up to a dozen or more lines from one boat.

Relative Importance of Block 308

Fishing in this block represents from a fourth to a half of all reported party boat trips each year, with an eleven-year average of 36 percent. Its importance is further emphasized by the fact that from a fourth to three-fourths of all bass reported by party boats have been taken there each year since 1938.

A summary of annual totals of boat days, angler days and striped bass reported is given in Table 4. Inclusion of half-day boats would have

TABLE 4

Summary of Party Boat * Reporting From Block 308

Year	Reported boat days		Angler days		Striped bass		
	Number	Percent of annual total †	Number	Percent of annual total †	Number	Percent of annual total †	Average weight
1938	591	29.8	3,248	31.3	7,262	38.5	4.1
1939	1,083	38.2	6,040	40.0	17,952	44.5	4.6
1940	1,251	31.9	6,369	32.0	18,394	39.0	5.6
1941	900	22.7	4,575	21.3	11,378	26.0	4.9
1942	533	32.7	3,099	35.5	8,389	44.3	4.3
1943	439	32.3	3,180	35.8	9,120	44.5	4.2
1944	333	38.7	2,674	51.2	5,880	55.2	3.6
1945	796	42.6	5,165	45.5	14,142	59.2	5.2
1946	1,189	43.5	7,079	48.9	13,963	60.0	4.9
1947	1,698	48.7	11,124	57.9	26,716	70.7	5.5
1948	1,082	35.4	6,375	41.5	13,087	47.6	4.2
Totals	9,895		58,928		146,283		

* Does not include half-day boats.
† Annual total reported by party boat operators.

increased the relative importance of Block 308 appreciably. In explanation of these figures it should be reemphasized that the party boat fishery is only a small fragment of the whole striped bass fishery, and that reporting has been incomplete and has varied somewhat in its degree of completeness. Data such as those in Table 4 can tell us a lot about major changes in the amount of fishing which occurred in the different blocks in past years, but it must be kept in mind that they provide only an indication of what happened. The actual figures themselves are not of much value, but the changes which occur in them are often highly informative. It must be emphasized that these limitations do not apply to the average catches or average weights which will be discussed, but only to totals such as those in Table 4.

Some idea of recent fluctuations in the relative importance of Block 308 can be gained from the solid line in Figure 54, which shows the per-

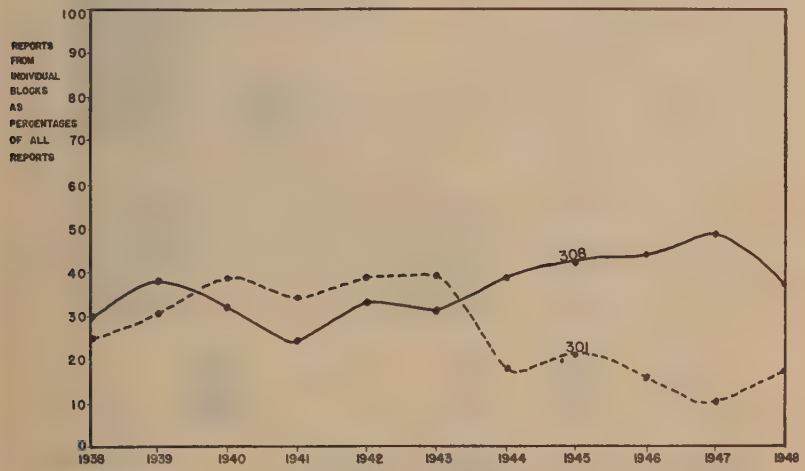

FIGURE 54—Fluctuations in the relative importance of Blocks 308 and 301 in the striped bass party boat fishery

centages of all reported trips made there each year since 1938. The dotted line shows corresponding percentages for Block 301 (San Pablo Bay), discussed in the next section. It is interesting to note that 308 accounted for almost half of all party boat fishing for striped bass reported in 1947. The consistency with which this block produces good bass fishing year after year may depend in no small measure upon the fact that any fish passing up or down the river must funnel through the Carquinez straits. In doing so, they concentrate themselves within the most intensively scouted part of the whole fishing area. Since they are an anadromous species, most of the adult population probably passes through the Straits each year on its journey to and from the main spawning grounds in the Central Valley, and many immature individuals must also do so in the course of the rather haphazard feeding movements they are known to make (Clark, 1936).

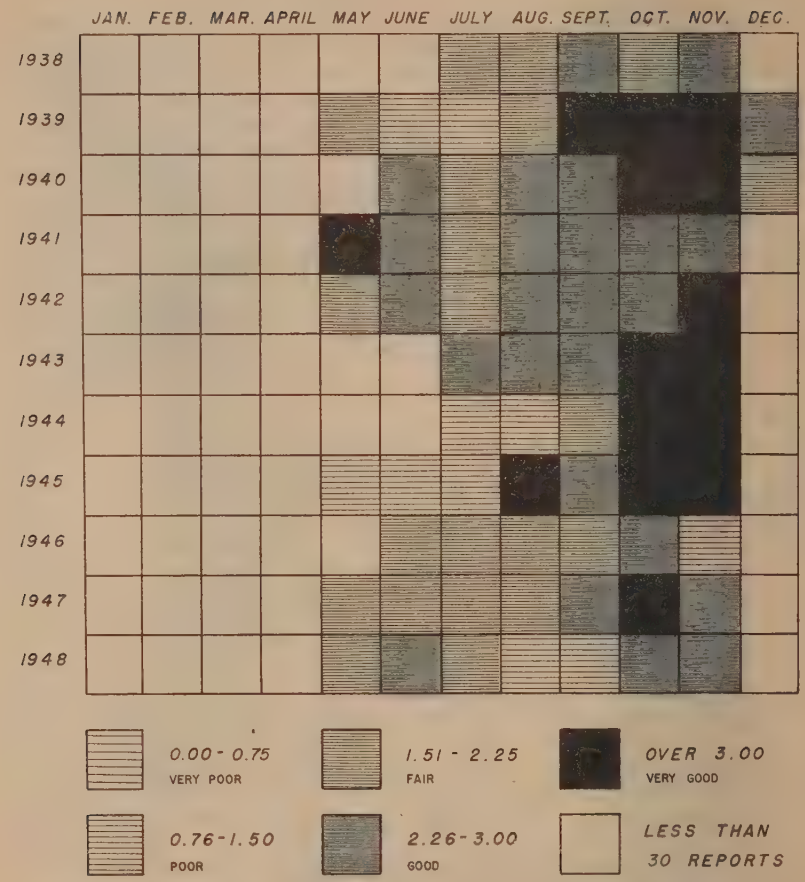

FIGURE 55—Average number of striped bass per angler per day in Block 308, for the years 1938 through 1948. Each square represents catches reported by party boats for one calendar month

Fluctuations in the Quality of Striped Bass Fishing in Block 308

The average daily catch of party boat anglers is our best yardstick of striped bass abundance. The type of chart shown in Figure 55 helps considerably to make large volumes of average catch figures meaningful. There is a corresponding diagram for each of the other fishing blocks and the six together represent the essence of this report. It will be noted that the hatching in Figure 55 is horizontal to avoid confusion with the partner diagrams showing average weights, in which the hatching is vertical. Data on which these diagrams are based were too bulky for inclusion in full and only illustrative samples are shown. Table 4, already discussed, indicates the volumes of records received from 308 in the different years and Table 5 shows the monthly samples for 1947, to illustrate seasonal changes in the amount of fishing.

Figure 55 shows the average daily angler catch in Block 308 by months for the period 1938 through 1948. It is based on a total of some

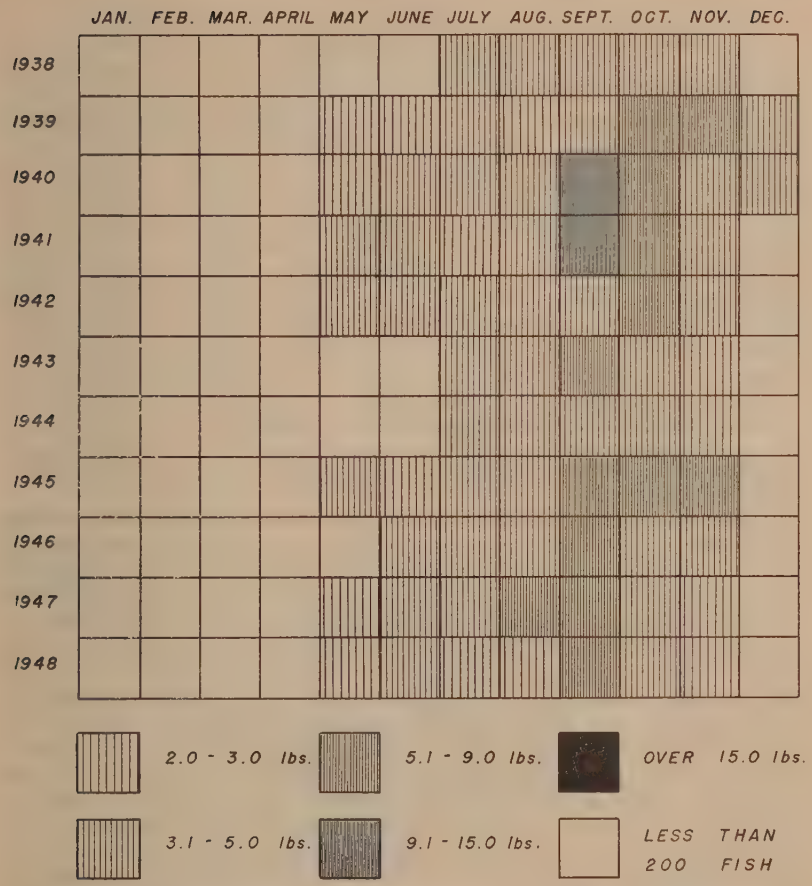

FIGURE 56—Average weight of striped bass reported by party boats from Block 308. Each square represents one calendar month

10,000 reported daily party boat trips representing some 60,000 angler days of striped bass fishing. Each square represents the month indicated at the top for the year shown at the left margin, and the darker the square the better the fishing. Generally speaking, an average catch of three fish per angler per day, shown by the black squares, indicates excellent fishing and, we presume, a high level of abundance of striped bass. Similarly, an average catch under 0.75, shown by the lightest hatching, represents very poor fishing and a correspondingly low level of abundance. There is less certainty about this latter assumption, however, because striped bass angling is sometimes quite poor even when the fish are fairly abundant, particularly during the winter. Three intermediate grades of fishing are represented by increasing intensities of hatching, as shown by the legend beneath Figure 55. It will be recalled that blank squares indicate inadequate samples of less than 30 logs. The

TABLE 5

Monthly Totals of Party Boat Records From Block 308 in 1947, Excluding Half-day Boats

Month	Number of operators reporting	Boat days reported	Angler days reported	Striped bass reported
January	0	0	0	0
February	0	0	0	0
March	0	0	0	0
April	4	13	76	89
May	6	35	126	230
June	19	98	651	1,404
July	31	200	1,233	2,151
August	38	376	2,476	4,157
September	50	652	4,537	12,075
October	39	300	1,892	6,242
November	10	* 24	133	368
December	0	0	0	0
Totals		1,698	11,124	26,716

* Half-day records used to obtain an adequate sample for inclusion in Figure 55.

bag limit of five fish is responsible for the fact that the top grade of fishing is only three plus.

The relationship between the quality of fishing and the average daily catch is somewhat complicated by the size of the fish involved. In this connection, Figure 56 is of interest. It shows the average reported weights of the fish upon which Figure 55 is based, on exactly the same grid. By putting the two together, it is possible to obtain at a glance a general idea of the average daily catch and the average weight for any desired month during the past 11 years. Figures 55 and 56 show clearly the strongly-developed seasonal pattern which is so characteristic of Block 308. The best fishing regularly occurs during the fall bait-fishing season, when average catch and average weight usually reach simultaneous peaks. The monthly totals in Table 5 are of interest in this connection. Fishing is also almost always good during November, although by then the bass caught are quite small and the amount of fishing is greatly reduced. The trolling season, extending roughly from June through August, is more erratic than the fall season. In some years it is quite good, but in others it is quite poor.

One of the most characteristic features of striped bass fishing in Block 308 is the regularity with which the same general pattern is repeated year after year. Fishing has been at least fairly good during most of the five-month period, July through November, in each of the 11 years for which there are records. There has been variation, of course. Generally speaking, fishing appears to have been somewhat poorer during the five-year period just ended than it was during the preceding five years. The implications of this trend are discussed in later sections. Suffice it here to say that the decline does not appear to be very serious. It is interesting to note that fishing was quite poor in 1938, the first year for which there are records. Moreover, the fish caught were unusually small, as can be seen from Figure 56. Part of the constriction apparent in 1944 and 1945 may have resulted from reduced fishing during the war, already mentioned, which probably decreased the efficiency of scouting for the fish. Gasoline restrictions encouraging short trips may also have had something to do with it.

A complicating factor which must be kept in mind when interpreting Figures 55 and 56 is that the large bass caught in Block 308 during the autumn are believed to be on an annual migration up the river, and conditions influencing the speed with which the schools pass through the area may have a marked effect on the amount of good fishing there in any particular year. To illustrate, a great school of bass was discovered by the party boat operators near Crockett in late September of 1947. It remained in a rather restricted area for some weeks and provided phenomenal fishing the whole time. Reports of livery boat operators, confirmed by examination of some unusually good records kept at Wiltze's Resort, a boat livery near Port Costa, indicate that a similar situation existed around Martinez in 1945, when the large fish remained in that area for many weeks. Figures 55 and 56 show that excellent catches of large bass were also made by party boats in Block 308 for several months during the fall of that year. However, if these large fish had passed through the area rapidly, as certain facts suggested that they did in 1948, the over-all picture might have been quite different, although there would have been the same number of striped bass. This indicates the danger of putting too much emphasis on catch records for a single year.

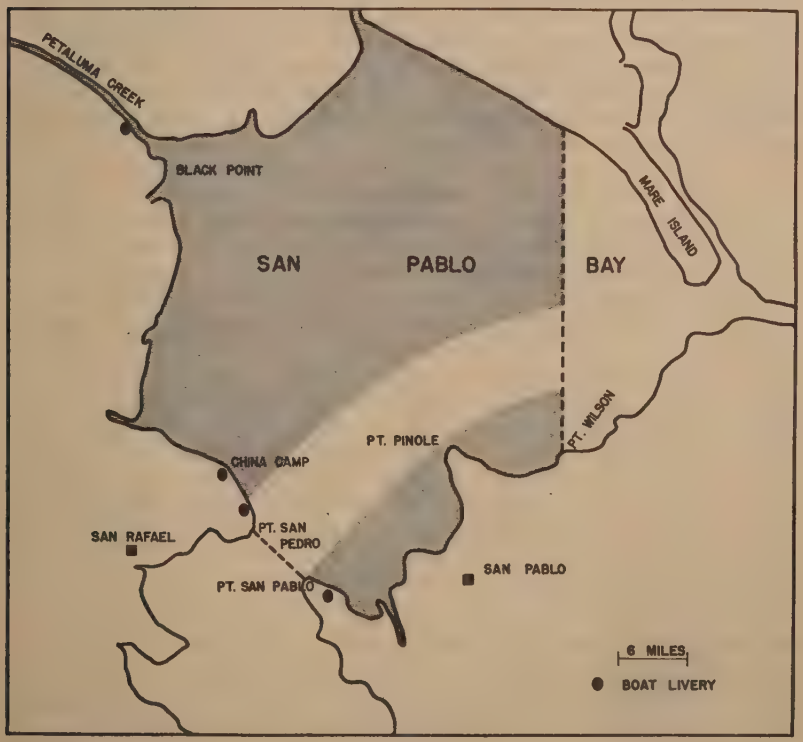

FIGURE 57—Fishing Block 301. Broken lines show its boundaries. Shaded areas are shallow water

RECORDS FROM BLOCK 301—SAN PABLO BAY

Description of Fishing Block 301

This block includes all of San Pable Bay west of Point Wilson. Most of it is rather shallow, as can be seen from Figure 57, in which depths under 10 feet are shaded. Actually, much of this shaded area is less than five feet deep. The water in San Pablo Bay is brackish in the spring and its salinity approaches that of the ocean during summer and fall. Party boats fish mainly in the unshaded area, although the flats are also fished extensively at times. Bait fishing predominates.

Relative Importance of Block 301

Block 301 has fluctuated greatly in relative importance during the 11 years covered by the records. A considerable degree of variation appears to be characteristic of the region. In 1947, the worst year, it accounted for only about 10 percent of the total reported days of party boat fishing. In 1940 and 1942, on the other hand, the corresponding figure was almost 40 percent and it was consistently 25 percent or more during the six-year period 1938 through 1943. These figures are given in Table 6, along with totals of angler days and striped bass caught. As was the case with Block 308, the three types of totals parallel each other rather closely. The recent decline in the importance of 301 is brought out clearly by the dotted line in Figure 54 in the preceding section. It is still too early to say whether it is a passing phase or a permanent change, although the former is the more probable. April fishing in San Pablo Bay was excellent in 1949, for the first time in six years, and this is a hopeful sign.

TABLE 6

Summary of Party Boat * Reporting From Block 301

Year	Reported boat days		Angler days		Striped bass		
	Number	Percent of annual total	Number	Percent of annual total	Number	Percent of annual total	Average weight
1938	495	25.0	2,670	25.7	3,605	19.1	8.1
1939	861	30.4	4,789	31.7	9,637	23.9	8.3
1940	1,514	38.6	8,082	40.6	17,796	37.7	7.1
1941	1,354	34.1	7,785	36.2	14,061	32.1	5.8
1942	633	38.9	3,642	41.7	7,157	37.8	4.4
1943	539	39.6	3,789	42.7	6,846	33.7	4.6
1944	147	17.1	912	17.4	1,649	15.5	6.3
1945	394	21.1	2,923	25.7	5,027	21.1	7.4
1946	424	15.5	2,500	17.3	3,348	14.4	5.6
1947	313	9.0	1,842	9.6	3,223	8.5	6.1
1948	518	17.0	2,900	18.9	6,373	23.2	4.4
Totals	7,192		41,834		78,722		

* Does not include half-day boats.

Fluctuations in the Quality of Striped Bass Fishing in Block 301

The seasonal pattern of fishing in this block, shown in Figure 58, is quite unlike that in Block 308, already discussed. Figure 58 represents some 7,000 party boat days and some 40,000 angler days of striped

TABLE 7

Monthly Totals of Party Boat Records From Block 301 in 1940, Excluding Half-day Boats

Month	Number of operators reporting	Boat days reported	Angler days reported	Striped bass reported
January	1	1	3	0
February	1	1	4	0
March	8	16	67	152
April	23	104	446	1,281
May	30	169	767	1,893
June	31	197	1,029	2,235
July	23	95	489	735
August	13	29	129	132
September	40	192	1,158	1,221
October	66	523	2,971	7,010
November	29	174	962	2,991
December	4	13	57	146
Totals		1,514	8,082	17,796

bass fishing. Monthly totals for 1940 are summarized in Table 7 to provide a general idea of the magnitude of the samples upon which Figure 58 is based.

Instead of the single peak of good fishing each fall which is so characteristic of 308, Block 301 shows a fairly obvious double peak in most years. A period of at least fairly good fishing in the spring is usually followed by another in the fall, with an intervening period of very poor fishing. Examination of the ovaries of adult bass taken near China Camp in the spring revealed that some of them were nearly ready to spawn, while on other occasions spent fish were encountered. Both upstream and downstream spawning migrants are apparently involved in the spring and early summer fishery. The fall fishing peak, centering in October, is one of the most consistent periods of good fishing revealed by the records, having averaged over 2.26 fish per angler day in nine of 11 years. However, periods of good fishing are characteristically briefer than in Block 308, even in the fall.

One of the most interesting facts revealed by Figure 58 is that except for October no single month has provided good fishing in Block 301 in more than two or three of the 11 years of record. Apparently it is normal to have only two or three months of good fishing in San Pablo Bay each year, and to have the good months vary from year to year, except for October, which is good consistently.

Weights of striped bass reported from Block 301 are shown in Figure 59, which is comparable with the weight diagram for Block 308 already described. A comparison of Figures 58 and 59 reveals that large fish are ordinarily abundant in San Pablo Bay only during September and October. High average weights in other months have nearly always coincided with periods of poor fishing. Conversely, good fishing in the spring and early summer has almost always been characterized by low average weights, although, of course, some large fish are caught. It will be remembered that the same general situation existed in Block 308. It has been remarkably consistent throughout the 11-year period, and can

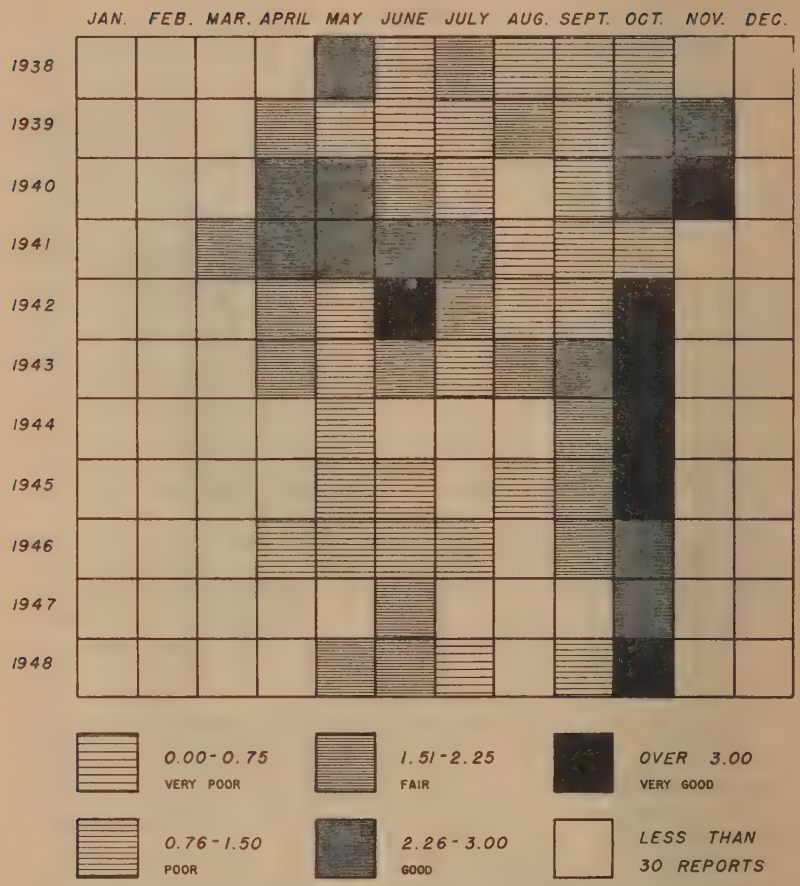

FIGURE 58—Average number of striped bass per angler per day in Block 301, for the years 1938 through 1948. Each square represents catches reported by party boats for one month

therefore be considered normal. The influx of large fish in the fall reflects their general movement up into fresh water beginning about September of each year. Most of them are apparently elsewhere during the summer. Changes in feeding habits may also have something to do with the situation. There is reason to believe that the fish may feed to a greater extent on the bottom in the fall than in the summer, when they appear to scatter vertically to feed on anchovies and other small fish. They will obviously be easier to locate and to catch when they are concentrated in a single

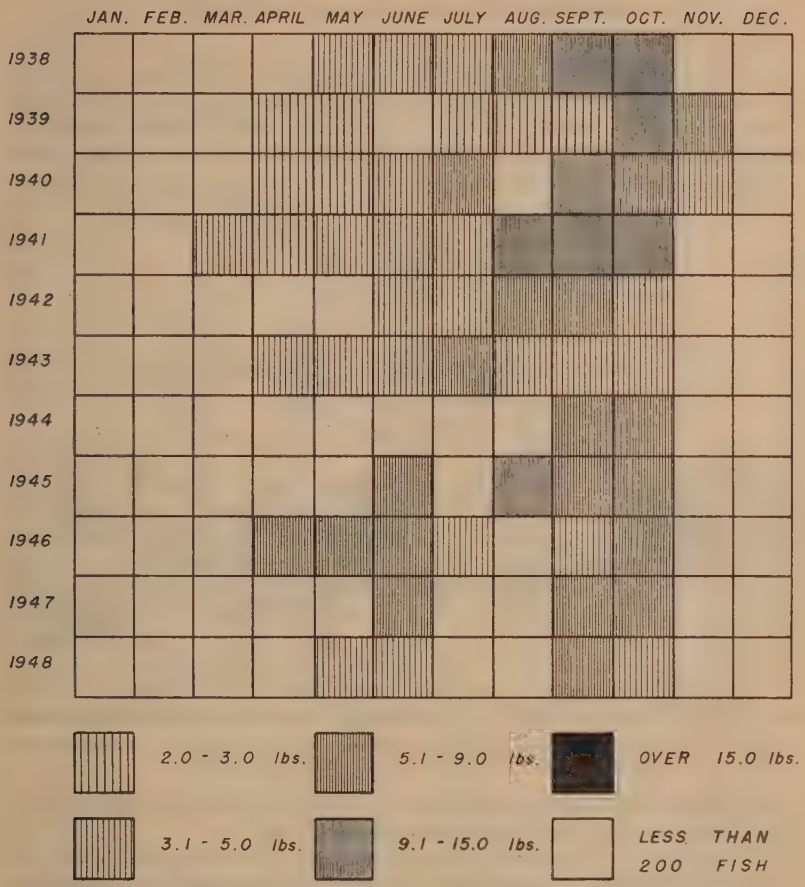

FIGURE 59—Average weight of striped bass reported by party boats from Block 301. Each square represents one calendar month

layer on the bottom. However, these ideas represent little more than speculation at the present time.

Summer fishing in Block 301 probably depends on relatively small numbers of resident fish, or on schools which pass through it on feeding migrations. This could explain its relative instability.

1949 is proving to be a year of relatively good spring fishing in Block 301, and it may well be that the recent slump in the importance of this area is about over.

RECORDS FROM BLOCK 303—THE DELTA

Description of Fishing Block 303

This region, shown in Figure 60, is a maze of interconnecting channels continually churned by tidal currents. There are also three sizable areas which are relatively free of current and rather shallow; these are stippled in Figure 60. They cover farmlands which were flooded when

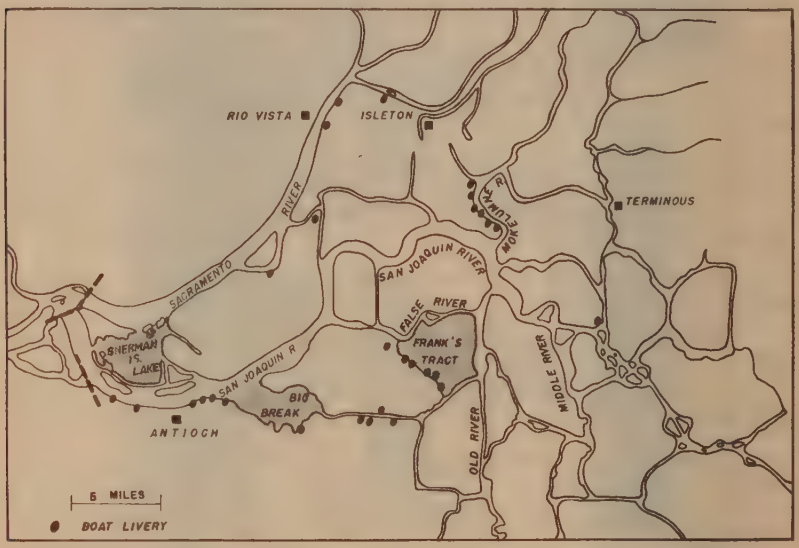

FIGURE 60—Fishing Block 303. All waters west of the broken line have been included in this block. Stippled areas are 10 feet or less deep

levees broke. The large striped bass enter them in some numbers during the winter, and they are favored fishing grounds.

The water is ordinarily fresh or nearly so throughout the year in Block 303. In very dry years salinity may rise somewhat in the autumn.

Striped bass angling goes on in most parts of this block at one time or another during autumn, winter and spring. The main San Joaquin River and adjacent channels and the flooded areas already mentioned are particularly important. Other sections such as the main Sacramento River and the lesser known sloughs are also fished extensively at certain times. Locations of boat liveries, shown in Figure 60, give a good indication of the centers of fishing activity.

Relative Importance of Block 303

The Delta has become increasingly important in the party boat fishery in recent years. The boats did not move up the river in the winter to any extent prior to 1944, judging from the fact that the records received from the area consistently formed less than 4 percent of the annual total from 1938 through 1943. In 1944 they increased to about 10 percent of the annual total and there has been a steady rise since then to about 35 percent in 1948, shown in the third column in Table 8. This

TABLE 8

Summary of Party Boat Reports From Block 303

Year	Reported boat days		Angler days		Striped bass		
	Number	Percent of annual total	Number	Percent of annual total	Number	Percent of annual total	Average weight
1938	58	2.92	247	2.38	401	2.12	3.47
1939	98	3.45	341	2.26	193	1.96	3.06
1940	155	3.94	549	2.76	773	1.64	10.56
1941	118	2.97	441	2.05	533	1.22	11.38
1942	62	3.80	199	2.28	261	1.38	5.41
1943	44	3.23	131	1.47	297	1.45	2.86
1944	87	10.11	303	5.80	698	6.56	4.55
1945	398	21.29	1,914	16.86	2,961	12.40	6.27
1946	844	30.85	3,586	24.76	4,540	19.52	7.69
1947	1,185	33.98	4,872	25.34	5,950	15.76	7.04
1948	1,074	35.18	4,158	27.10	6,453	23.51	4.87
Totals	4,123		16,741		23,060		

increase is believed to be independent of any change in abundance or distribution of striped bass and to represent merely an expansion of the party boat fishery into regions not exploited by it previously. Corresponding enlargement of livery boat facilities is known to have occurred in the Delta and all types of fishing activity have been increasing there since the war. The growing metropolitan centers of the San Francisco

TABLE 9

Monthly Totals of Party Boat Records From Block 303 in 1947

Month	Number of operators reporting	Boat days reported	Angler days reported	Striped bass reported
January	21	103	342	421
February	24	173	680	899
March	23	151	669	745
April	13	75	297	463
May	11	61	248	444
June	3	8	27	120
July	4	8	34	41
August	3	12	44	62
September	6	21	110	176
October	24	78	328	284
November	40	318	1,458	1,299
December	27	177	635	996
Totals		1,185	4,872	5,950

Bay Area are apparently looking farther afield for their recreation and the recent upswing of angling pressure in Block 303 can be attributed to this fact.

A summary of the party boat records from Block 303 in 1947 is given in Table 9.

Fluctuations in the Quality of Fishing in Block 303

Average catch on party boats fishing in the Delta is shown in Figure 61, in the same manner as in preceding sections. The top two-thirds of

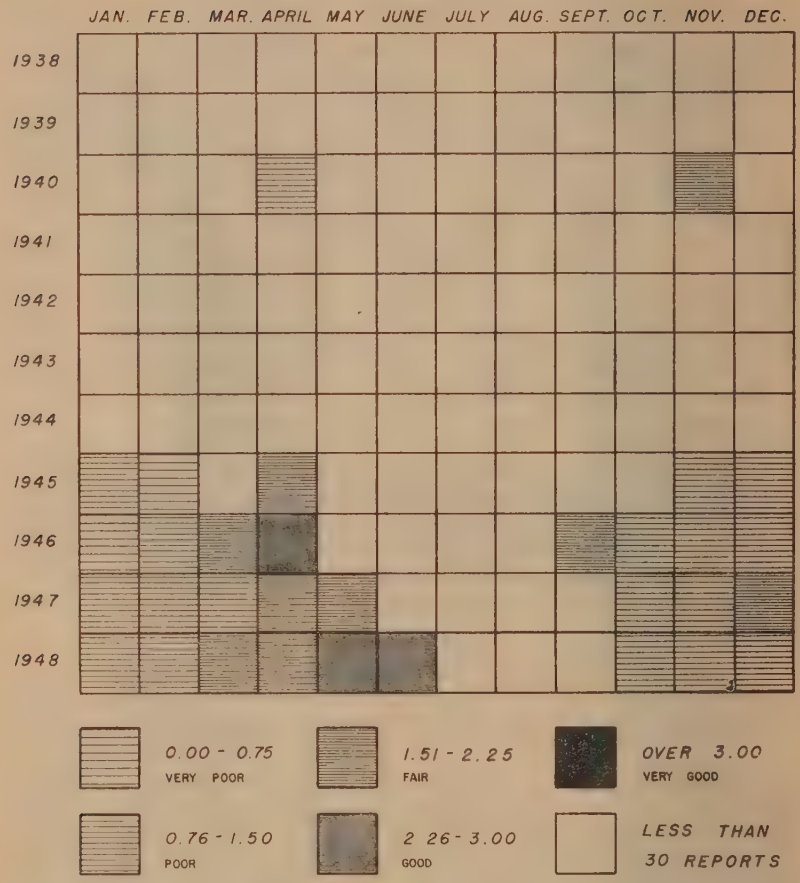

FIGURE 61—Average number of striped bass per angler per day in Block 303, for the years 1938 through 1948. Each square represents catches reported by party boats for one month

the figure are virtually blank because there were not enough records before 1945 for adequate samples. It has already been emphasized that this is not connected in any way with fishing quality.

Since 1945 party boat fishing has been fairly extensive and the last four years plotted in Figure 61 give a good picture of what happens in Block 303 each year. Fishing begins in September or October and continues through the winter and into the spring. It is never very good, compared with the best fishing in Blocks 308 and 301, except in the spring, when it is at its best for about a month. Striped bass become sluggish during cold weather. They bite poorly and are hard to hook

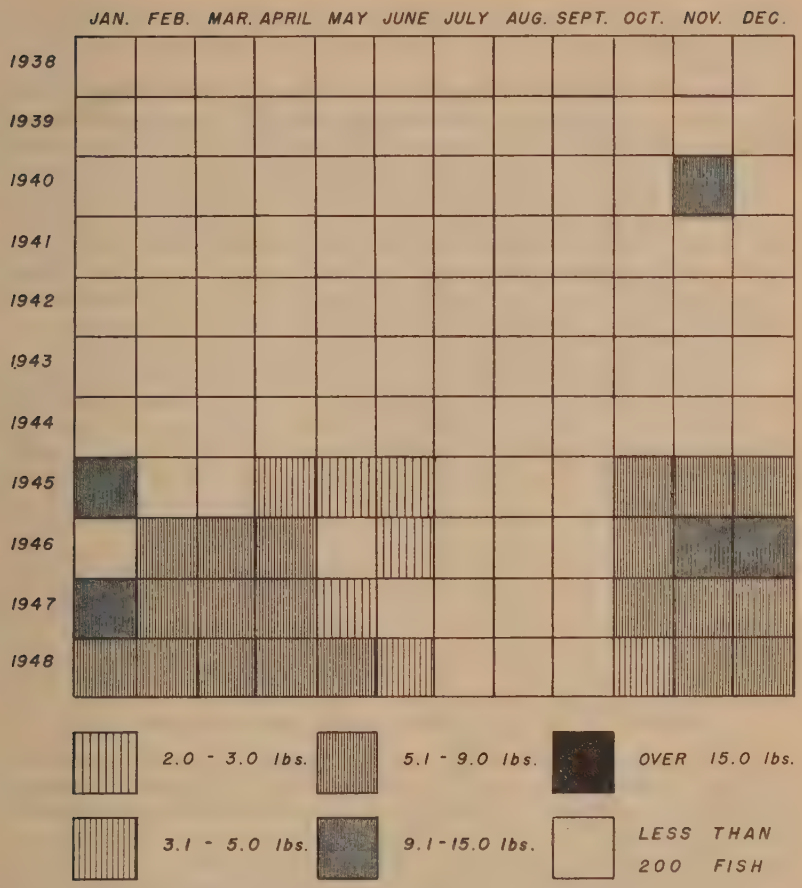

FIGURE 62—Average weights of striped bass reported by party boats from Block 303. Each square represents one calendar month

when they do bite. As a result, fishing is generally at a low level during the winter. However, the fish which are caught are usually of good size, as can be seen from the weight chart in Figure 62. Average weights have exceeded five pounds consistently and have frequently been over nine pounds. Fishing does not have to be very good to keep the party boats operating when this is the case. It is interesting to note that average weight decreases sharply each year during the last month or two of the season. Field observations suggest two possible explanations. One is that the large females are known to bite less readily as they approach spawning condition. The other is that the large bass apparently drop back to salt

water rapidy after spawning, with little feeding en route. Few large spent fish are taken by anglers in fresh water, although of course some are caught.

In each of the last three years there has been one month in the spring when party boat fishing in the Delta has been fair to good and average weights have exceeded five pounds. In 1946 and 1947 the month was April and in 1948 it was May. Spawning was also retarded about a month in 1948, because of unusually cold weather in late spring. Everything considered, there is little doubt that the main spring run in the Delta each year occurs as the water warms up and the striped bass become active again and pass through the various channels toward their spawning grounds. Certain livery boat records and other information leave no doubt that such runs have occurred regularly in the past, although we lack the necessary party boat records to detect them prior to 1945.

The fishing characteristics of Block 303 are more obviously dependent upon weather conditions and striped bass migrations than those of other areas. Activity begins in the autumn, as the mature bass move up into the area from salt and brackish water. Fishing is poor during the winter because of low temperatures. Good spring fishing is correlated with increased activity prior to spawning. Finally, during the summer only very small fish are present in the area, which is a nursery ground for yearlings and two-year-olds, and the whole Delta is of negligible importance from June through September except for catfishing. The same sequence occurs regularly each year. Returns from preliminary experiments in which more than three hundred large striped bass were tagged confirm the large-scale migrations shown by the catch records, and the two together provide proof which can scarcely be questioned.

RECORDS FROM BLOCK 488—UPPER SAN FRANCISCO BAY

Boundaries of this block are shown in Figure 63. Salinity approaches that of the ocean in the autumn but drops to about half that of sea water in the spring. Trolling around the various small islands, particularly the Brothers, Red Rock, and the Marin Islands is one of the most productive types of fishing. Some bait fishing also goes on.

Party boats operating in this area tend to concentrate on salmon fishing outside the Golden Gate when it is good. This has reduced the amount of scouting and fishing for striped bass in the last few years. The region has fluctuated in importance from negligible in some years to fairly important in others, as shown in Table 10. In five of the eleven years represented it accounted for about one-fifth of all reports. It was much less important in the other years, and has been almost negligible since 1945. The average daily catch of anglers fishing on party boats is charted in Figure 64, in the same manner as in preceding sections. June has provided fair to good fishing in seven of the 11 years. May and July have been the next best months. Each has shown at least fair fishing in four of the 11 years. Other months have been good only sporadically. This is clearly an early summer fishery.

Average weights of reported party boat catches, shown in Figure 65, have differed widely in the various scattered periods of good fishing in

FIGURE 63—Fishing Block 488. Boundaries are shown by the broken lines

TABLE 10

Summary of Party Boat Reports From Block 488

Year	Boat days		Angler days		Striped bass		
	Number	Percent of annual total	Number	Percent of annual total	Number	Percent of annual total	Average weight
1938	343	17.28	1,514	14.59	2,357	12.48	5.22
1939	236	8.32	1,010	6.69	1,145	2.84	6.18
1940	305	7.77	1,321	6.63	2,792	5.92	5.07
1941	689	17.35	3,456	16.08	7,653	17.48	5.62
1942	277	17.00	1,247	14.27	2,324	12.28	4.02
1943	236	17.34	1,246	14.03	2,725	13.28	6.40
1944	194	22.55	877	16.78	933	8.77	9.87
1945	202	10.81	974	8.58	1,084	4.54	9.51
1946	188	6.87	892	6.16	933	4.01	6.61
1947	96	2.75	442	2.30	381	1.01	7.06
1948	33	1.08	166	1.08	207	.75	6.07
Totals	2,799		13,145		22,534		

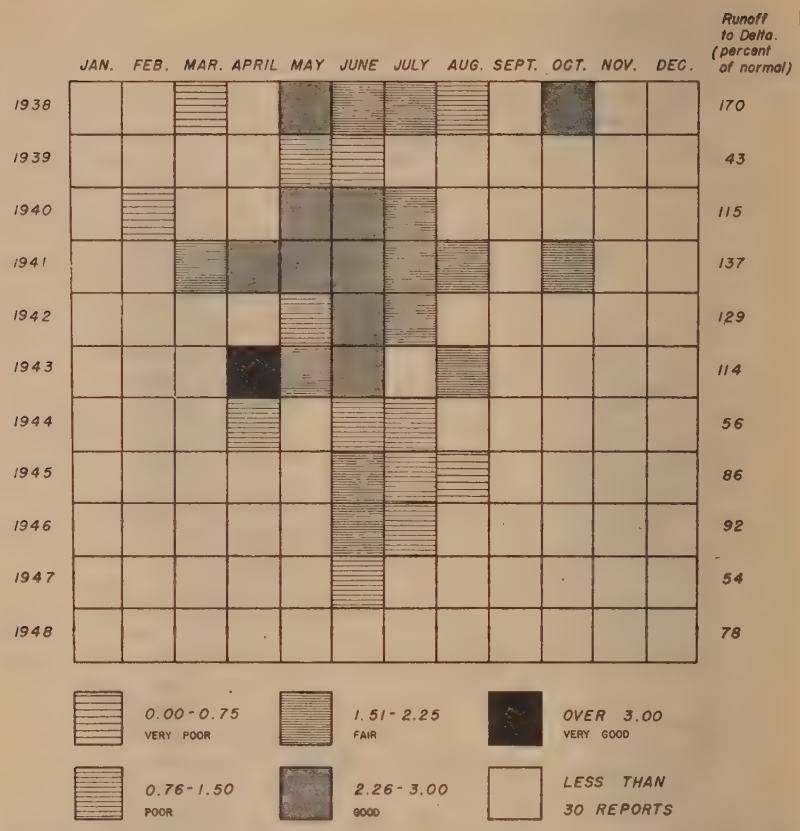

FIGURE 64—Average number of striped bass per angler per day in Block 488, for the years 1938 through 1948. Each square represents catches reported by party boats for one month

Block 488 shown in Figure 64. However, they have never fallen into the lowest category. They were very high in July of 1944 and 1945. Unlike most of the other blocks, this one shows no clear-cut annual pattern of average weights.

At first glance, Figure 64 suggests a declining fishery. A sharp tapering off since 1944 is certainly apparent. However, it is believed to have resulted primarily from a variety of causes which were unrelated to the over-all abundance of striped bass. The drawing away of the party boats by salmon fishing in the ocean in 1947 and 1948 has had something to do with it, but it is by no means the whole story. There is

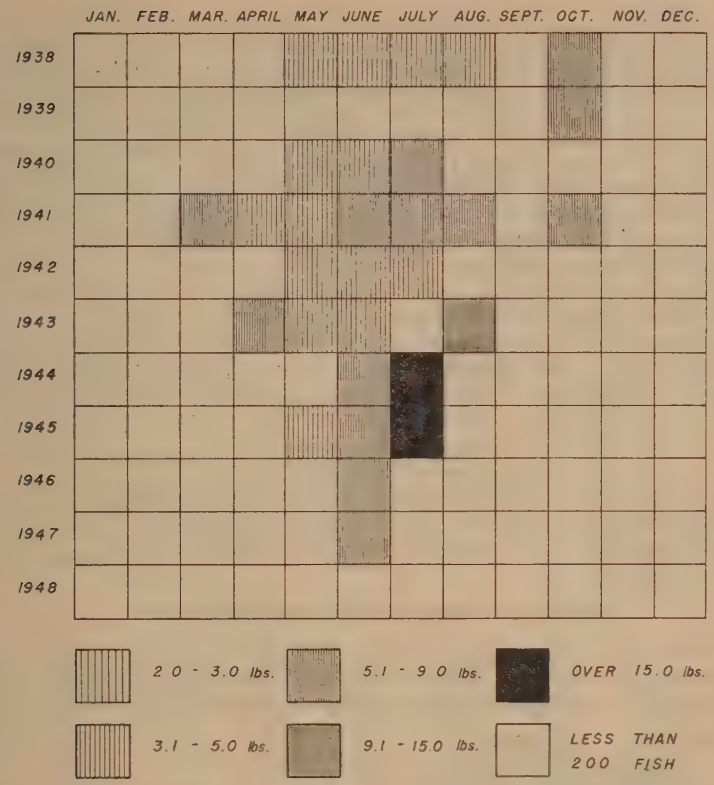

FIGURE 65—Average weights of striped bass reported by party boats from Block 488. Each square represents one calendar month

little doubt that bass fishing has actually been pretty poor in Block 488 since 1944. But does this indicate a depletion of striped bass or a change in conditions in San Francisco Bay? The latter is the more probable, for several reasons. In the first place, it is clear that the striped bass are migratory, and that San Francisco Bay represents their gateway to the Pacific Ocean. The extent to which they remain in the bay during the early summer, instead of passing out through the Golden Gate, will have a great deal to do with the extent and quality of fishing. This, in turn, undoubtedly depends upon a variety of factors, but we know almost nothing about them. Changes in the abundance or distribution of shrimps

and anchovies and other important food organisms could be very important. Another factor which cannot be overlooked is the recent increase in the discharge of raw sewage into the bay accompanying the accelerated development of the surrounding metropolitan areas during and after the war. The whole matter of pollution in the San Francisco Bay area is a problem in itself. Suffice it here to say that recently increased discharges of raw sewage have seriously polluted the waters in some sections of San Francisco Bay, and the results can scarcely have been beneficial to the striped bass or the fishery. It is fortunate that adequate treatment of most of this sewage in plants now under construction can be expected in the near future.

Salinity is another factor which may be tied into the picture in some way. There appears to be a relationship between the total runoff of the Sacramento and San Joaquin Rivers and the quality of striped bass fishing in Block 488. Runoff for each of the 11 years is shown to the right of Figure 64, expressed as a percentage of the 50-year normal (California Division of Water Resources 1948, Table 1). It was above normal in all five of the good fishing years and subnormal in the other six poor years. However, striped bass appear to be rather indifferent to changes in salinity as such and if a relationship actually exists it is probably indirect. It will be interesting to see if future years bear out the correlation. No comparable situations could be found in any of the other blocks.

RECORDS FROM BLOCK 302—SUISUN BAY

This area is less important than those already discussed, and will be given less attention. It extends from Point Edith eastward to the mouth of the Sacramento River, as shown in Figure 66. Grizzly Bay and

FIGURE 66—Fishing Block 302. Boundaries are shown by broken lines. Stippled areas are shallower than 10 feet

Honker Bay, stippled in this figure, are shallow water areas. The water ranges from fresh in the spring to brackish in the autumn, with considerable variation in different years. Striped bass fishing goes on also in the sloughs north of Suisun Bay, incompletely shown in Figure 66, but the party boats do not ordinarily operate there.

This block has been of negligible importance in the party boat fishery since 1941. It has never accounted for much of the total reported party boat fishing, as can be seen from Table 11, which shows annual totals of boat days, angler days, and striped bass reported since 1938. At the present time a few boats are operating sporadically from harbors in the area, but most of the fishing is from rented skiffs or private boats.

Observation of the livery boat fishery indicates that there is characteristically a good run of striped bass in Suisun Bay each autumn, even though party boat records have been too few to reveal it in recent years. This run clearly depends on the same fish which provide the good fall angling in the other blocks, and which must pass through Block 302 to reach the Delta.

TABLE 11

Summary of Party Boat Reports From Block 302

Year	Reported boat days		Angler days		Striped bass		
	Number	Percent of annual total	Number	Percent of annual total	Number	Percent of annual total	Average weight
1938	176	8.87	876	8.44	2,003	10.61	2.90
1939	509	17.96	2,740	18.14	10,744	26.60	3.06
1940	401	10.21	2,250	11.29	6,500	13.78	3.27
1941	282	7.10	1,414	6.58	3,701	8.45	3.27
1942	80	4.91	354	4.05	707	3.73	2.79
1943	93	6.83	487	5.48	1,497	7.30	2.77
1944	98	11.39	456	8.72	1,484	13.94	3.18
1945	73	3.90	343	3.02	658	2.76	3.95
1946	77	2.81	345	2.38	459	1.97	2.69
1947	154	4.41	729	3.79	1,425	3.77	3.13
1948	54	1.68	239	1.56	349	1.27	2.99
Totals	1,997		10,233		29,527		

Average catches for Block 302 for the various months during the past 11 years for which there were adequate samples are charted in Figure 67. It will be seen that the good fall run already mentioned is shown by these records in the years in which there was enough party boat fishing to give us a sample. However, on the average the fish caught were consistently small. Reported weights are shown in Figure 68. Perhaps the most unusual thing about this chart is the absence of any monthly samples averaging five or more pounds in weight. Small fish are characteristic of Suisun Bay, which is often referred to as the "kindergarten." That is probably one reason why there is relatively little party boat fishing there.

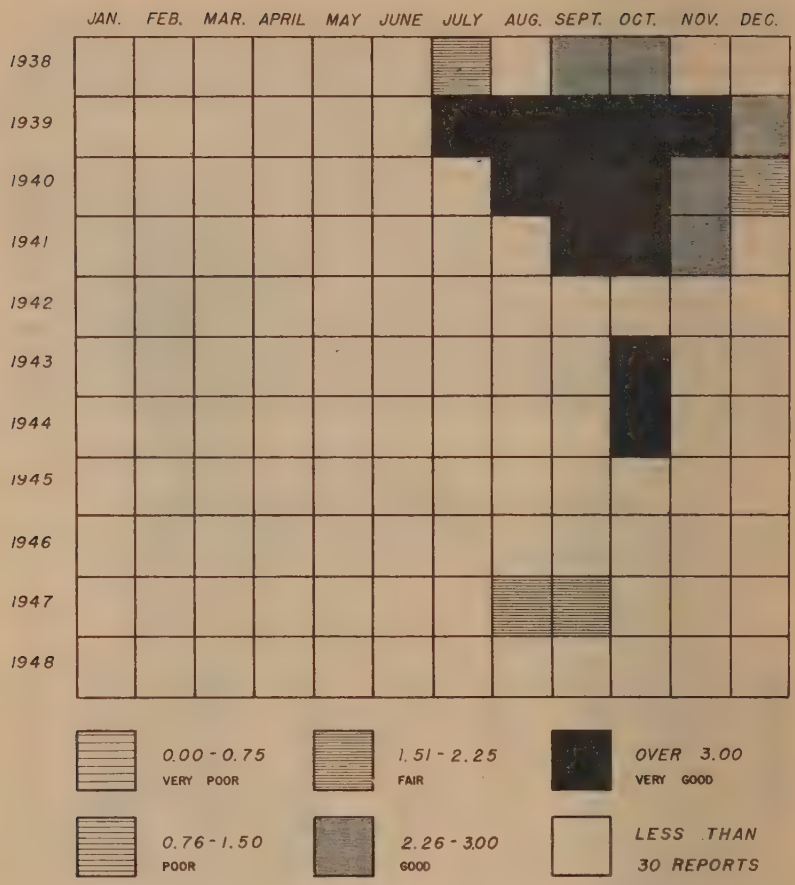

FIGURE 67—Average number of striped bass per angler per day in Block 302, for the years 1938 through 1948. Each square represents catches reported by party boats for one month

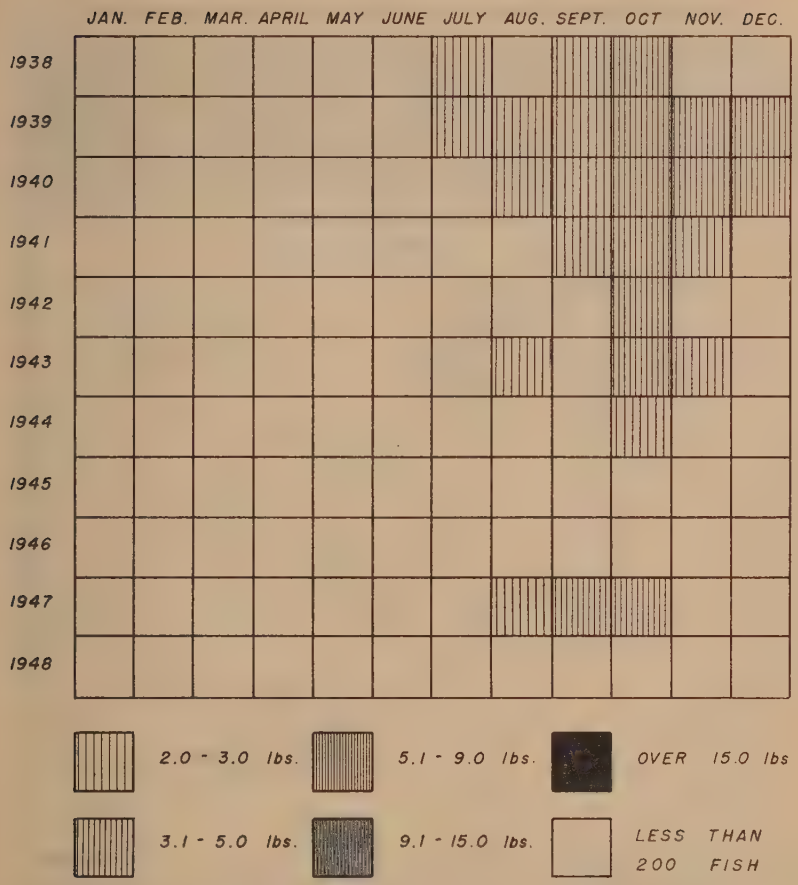

FIGURE 68—Average weights of striped bass reported by party boats from Block 302. Each square represents one calendar month

RECORDS FROM BLOCK 489—LOWER SAN FRANCISCO BAY

This area is also relatively unimportant. It includes all of the waters of San Francisco Bay south of the Bay Bridge, as indicated in Figure 69. Fishing usually centers around Mission Rock and Hunters Point. Elsewhere it is sporadic and almost negligible in importance. About 15 percent of all trips were reported from this block in 1938 and 1941, the two years in which the greatest activity appears to have occurred. Very few

FIGURE 69—Fishing Block 489. The northern boundary is shown by the broken line at the Bay Bridge. The shores of San Francisco Bay are the other boundaries

reports were received in other years, although there is a certain amount of scouting in the area each year. A summary of the reports received each year is given in Table 12.

Interpretation of the catch records, charted in Figures 70 and 71, is somewhat complicated by the fact that the favored fishing grounds were heavily restricted during the war, and part of the blankness of the record between 1941 and 1946 must be attributed to this fact. However, boats entered these areas freely in 1946 and 1947 and the poor record for these years can therefore be attributed to poor fishing.

This block has some unusual characteristics. Fishing is far more sporadic than elsewhere within the Golden Gate. The monthly average catch of anglers on party boats is consistently low, never having exceeded

2.26 fish per day in 11 years. However, the amount of fishing reported has rarely been sufficient to provide adequate samples of 30 logs per month, and most of Figures 70 and 71 are blank as a result. The considerable appeal of the area stems from the very large size of the fish caught. Average weights usually have exceeded nine pounds and several times have been over fifteen pounds. Fish are very large indeed when monthly averages are this high. As in the case of Block 488, this is a summer fishery, when there is any fishery at all.

TABLE 12

Summary of Party Boat Reports From Block 489

Year	Reported boat days		Angler days		Striped bass		
	Number	Percent of annual total	Number	Percent of annual total	Number	Percent of annual total	Average weight
1938	321	16.17	1,822	17.56	3,257	17.24	8.96
1939	47	1.65	188	1.24	112	.28	8.74
1940	299	7.61	1,353	6.79	924	1.96	1.45
1941	626	15.77	3,825	17.79	6,460	14.75	11.69
1942	44	2.70	198	2.27	94	.50	12.43
1943	10	.73	51	.57	28	.14	5.22
1944	1	.11	6	.11	0	.00	0
1945	6	.32	35	.31	0	.00	0
1946	14	.51	79	.55	18	.08	21.67
1947	41	1.18	217	1.13	70	.19	16.77
1948	292	9.56	1,500	9.78	984	3.58	17.54
Totals	1,701		9,274		11,947		

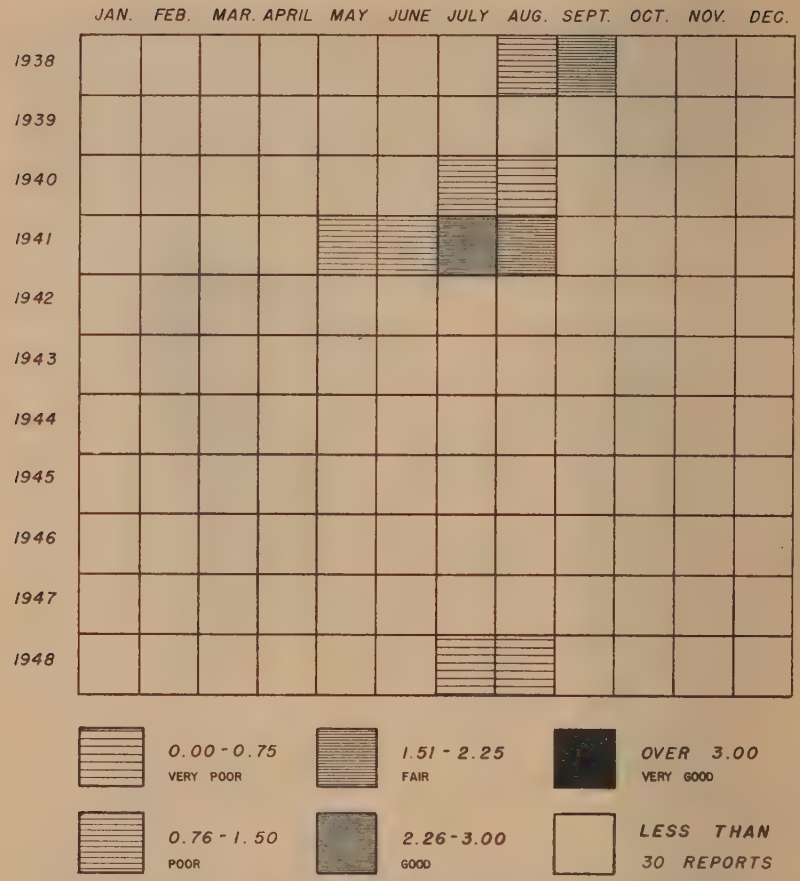

FIGURE 70—Average number of striped bass per angler per day in Block 489, for the years 1938 through 1948. Each square represents catches reported by party boats for one month

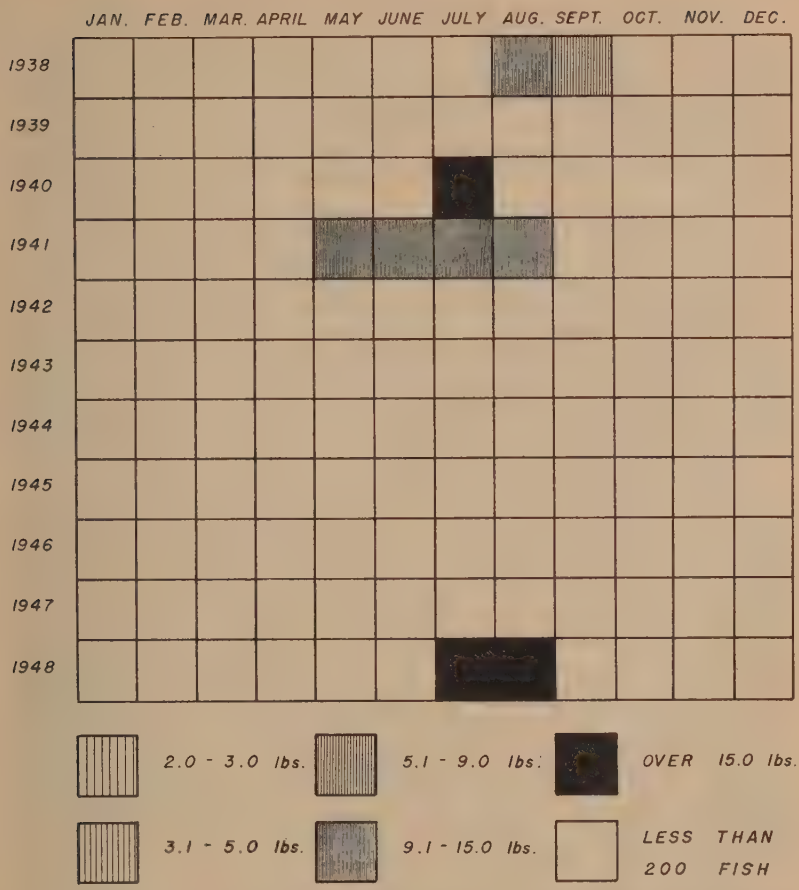

FIGURE 71—Average weights of striped bass reported by party boats from Block 489. Each square represents one calendar month

DISCUSSION OF THE CALIFORNIA STRIPED BASS FISHERY IN THE LIGHT OF THE PARTY BOAT RECORDS

Are the striped bass greatly reduced in numbers of late, compared with years past, as some sportsmen maintain, or are they about as abundant as ever, as others contend? This is a question of great interest and importance. Let us see what kind of an answer can be obtained from the party boat records, which are the best single source of information on the matter.

It is necessary, first of all, to outline some of the things which should be kept in mind in drawing conclusions from these records. For all their advantages over other types of records, they still have certain limitations. It will be recalled that each fishing block has a unique seasonal pattern, and that in most instances this pattern is related in a fairly obvious way to the migratory behavior of the striped bass. Moreover, the various blocks differ greatly in the regularity with which the characteristic pattern repeats itself from year to year. Combinations of seasons and areas which did not take such facts into consideration could be very misleading, and a combination of any sort is to be viewed with skepticism.

Another thing to keep in mind is that some fishing blocks provide more valuable records than others because the species is migratory and for other reasons as well. Records from summer fishing areas such as Blocks 488 and 489 (upper and lower San Francisco Bay) are apt to be misleading. A poor season there may simply mean that the fish are elsewhere, for we know very little about their whereabouts during the summer. Many undoubtedly enter the Pacific Ocean, but they are not caught there to any extent except during sporadic runs along the beaches north and south of the Golden Gate. On the basis of the large-scale movements of striped bass along the Atlantic Coast discovered by Merriman (1941), coupled with the occasional capture of individuals on our coast all the way from the Columbia River to Southern California, it is a reasonable assumption that a considerable portion of the body of fish which supports the good fall fishing in Blocks 308 and 301 is outside the Golden Gate during the summer, at least in some years. Thus, records from Blocks 488 and 489 must not be given too much weight.

Two other blocks are also of slight value. There has been so little party boat fishing and reporting in 302 (Suisun Bay) in recent years that the records do not show what has actually been going on. In the case of 303 (Sacramento-San Joaquin Delta) the party boat fishery has developed only recently, and there are virtually no records before 1945. Moreover, 303 is primarily a winter fishing area, and striped bass may be abundant in areas in which angling is poor when water temperatures are low. Average catches are probably not as good measures of abundance during the winter as at other times.

This leaves only Blocks 308 (Carquinez Straits) and 301 (San Pablo Bay), which are fortunately more satisfactory than the other four just mentioned. They lie on the main migration route, and it is reasonable to suppose that most of the population passes through them each year. The length of time which its various segments actually spend in these two blocks undoubtedly varies somewhat from year to year, and this factor as well as the general level of abundance will certainly influence the records. However, differences in speed of migration should cancel out

over a period of years and important trends should be fairly obvious. This further emphasizes the necessity of considering the records over a considerable period of years, for a real danger of misinterpretation exists if too much emphasis is placed upon one or two unusually good or bad years. A passing change in the behavior of the population resulting from an unusual environmental situation could easily influence the records markedly, and this should be kept in mind.

Blocks 308 and 301 have the added advantage that they are two of the most important party boat fishing areas, and together they usually provide the bulk of the records received each year.

One of the best ways to get a general impression of what has been happening in the striped bass fishery since 1938 is to examine Figures 55 and 58 carefully, interpreting them in the light of the preceding discussion and the material outlined in the sections dealing with Blocks 308 and 301. Any important reduction in abundance of striped bass should cause a general lightening of the horizontal strips of hatched squares in years of low abundance, while increasing abundance should cause a corresponding darkening. It is fairly obvious from these two diagrams and the discussion which accompanies them that no very important change has occurred one way or the other during the past 11 years. In fact, the stability shown by Block 308 is quite remarkable. One does obtain the general impression, however, from these two figures alone, and even more when Blocks 488 and 302 are added to the picture, that striped bass have been somewhat less plentiful since 1944 than they were during the five years previous, and this conclusion is borne out by total catch estimates derived from large-scale postal card surveys of state-wide angling catches, shown in the upper right part of Figure 72. These estimates are expressed as percentages of the 1939 (median) figure, because their absolute value is still uncertain, and they can be used with confidence only to express trends. In this latter connection they are entirely satisfactory, however, because comparable surveys were made each year. There is little reason to doubt that a minor decline in striped bass abundance has occurred during the last few years, but it must be emphasized that minor fluctuations of this sort are to be expected in populations of fish such as the striped bass. It is actually surprising that there have not been greater fluctuations than appear to have occurred since the species was introduced. It is interesting in this connection to review the old commercial catch records, which are graphed on the left side of Figure 72. Craig (1928) showed that the big decrease in total commercial catch after 1915, so apparent in the upper left graph, resulted more from restricted fishing than from reduced abundance of fish, although an earlier discussion by Scofield and Bryant (1926) suggests that there was perhaps also a passing decrease in abundance about that time. The matter is difficult to evaluate, and is interesting primarily because the difficulty of discovering any really severe down-swings in the population since its initial development in California is proof enough of its remarkable stability. It is unfortunate that the commercial records and the sport-catch records do not overlap, and therefore cannot be integrated onto a single scale. However, the "incidental" catch of striped bass in salmon and shad nets for several years after commercial fishing for that species ceased in 1931 was about the same as the previous

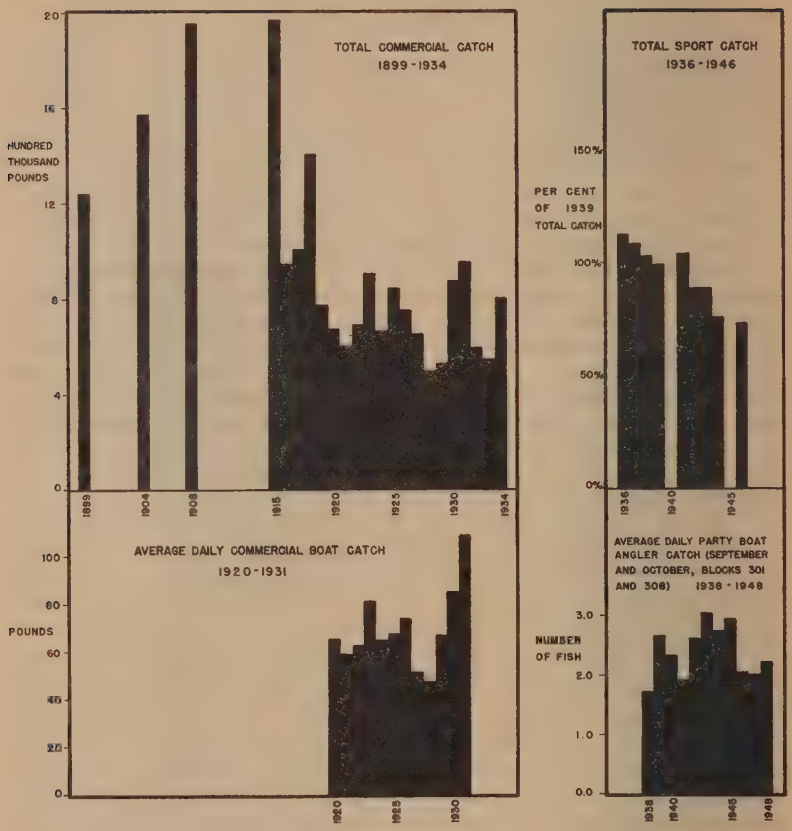

FIGURE 72—Summary of California sport and commercial catches of striped bass

total catch, and this fairly well proves that there was no decrease in abundance from 1931 to 1934. The actual gap between the two types of records is accordingly reduced to a single year, and the characteristic stability of the fishery can safely be assumed to have bridged that brief interval.

The graph in the lower right corner of Figure 72 requires some explanation. Mere visual inspection of the average-catch grids for Blocks 308 and 301 is a somewhat less objective treatment of the records than one might wish, although it appears to be about as sound an approach as any. At any rate, a numerical index of the abundance in any year is desirable. A figure which represents the quality of fishing in Blocks 301 and 308 at the height of the fall season appears to offer the greatest possibilities in this connection. These blocks were selected for reasons which will be obvious from preceding discussions and the months of September and October were chosen because they cover the period when the greater part of the main population is believed to be present there

most consistently. The index which has been adopted is an average of the four average-catch figures for September and October in Blocks 308 and 301, shown in Table 13 and Figure 72. It has fluctuated from slightly less than two to about three fish per angler per day over the eleven year

TABLE 13

Derivation of Average Daily Party Boat Catch Shown in Figure 72

	Average catch per party boat angler				Average
	Block 308		Block 301		
	September	October	September	October	
1938	2.52	2.10	1.28	1.16	1.77
1939	3.20	3.62	1.48	2.32	2.66
1940	2.44	3.40	1.05	2.36	2.31
1941	2.54	2.59	1.17	1.24	1.89
1942	2.82	2.93	.97	3.68	2.60
1943	2.62	3.46	2.67	3.31	3.02
1944	1.95	3.62	2.03	3.48	2.77
1945	2.84	3.67	1.90	3.30	2.93
1946	2.08	2.66	1.73	2.67	2.29
1947	2.66	3.30	*0.00	2.54	2.13
1948	1.40	2.92	1.15	3.34	2.20

* Inadequate sample.

period. The general picture is one of stability. This index is subject to criticism on the grounds that it is based on the time and place when the fish are most concentrated, and it will therefore probably decline more slowly than actual abundance. Its failure to drop noticeably since 1945, when other information suggests that a slight decline has actually occurred, bears out this criticism. However, other combinations are even less satisfactory.

It is possible to draw some interesting inferences about fluctuations in the numbers of small fish in the population from the average catch and average weight diagrams for the various blocks. An unusual abundance apparently occurred in 1939 in Block 302 (Suisun Bay) ; the next year it extended into 308 (Carquinez Straits) and 301 (San Pablo Bay), and it continued into 1941. There appears to have been remarkably good summer fishing during these years, and it will be noted from the various weight diagrams that the fish were consistently small. This situation may have been largely responsible for the belief not infrequently encountered among anglers that there has recently been a serious decrease in abundance. Sportsmen sometimes claim that formerly they were able to go out and "catch a limit" anytime, and apparently this was pretty much the case over a wide area about 1940. Since this was followed by a return to what is apparently a more nearly normal situation of relatively low abundance during the summer months, it is not difficult to understand how a casual angler might gain a strong but altogether false impression of a serious decline in abundance.

It is possible that one or more unusually strong year classes came into the fishery between 1939 and 1941. The abundance of small fish in Suisun Bay a year earlier than in San Pablo Bay fits well into the picture, for Suisun Bay is a nursery ground for small fish. Some of the

party boat operators still remember and talk about the phenomenal abundance of small fish there around 1940.

Fairly large fluctuations in the total size of the population and the relative numbers of the various size groups composing it are normal in a fish population of this sort, and should be expected. It must be emphasized, however, that considerable study over long periods is necessary if they are to be understood fully, and at the present time we have a great deal to learn in this connection. One of the most promising sources of information is the relative concentration of young bass of the year on the nursery grounds each summer. Some interesting speculations are already possible on the basis of only two years of observation of the baby bass. The abundance of small fish of the year over wide areas, discovered in 1947, has been described previously (Calhoun and Woodhull 1948). The next summer these same fish were six or seven inches long, and they were thick enough throughout the Delta to cause considerably more comment about "bait stealers" than had been apparent in 1946 or 1947. Then, in 1948, the small fish of the year were found to be equally or more abundant than they had been in 1947. The situation is promising, and it is going to be interesting to see if 1950 and 1951 provide an abundance of small catchable fish. Of course, we lack information about concentrations of fish of the year in earlier summers, and the 1947 and 1948 year classes may not actually be anything out of the ordinary.

In summary, it appears to be safe to conclude that the striped bass population is maintaining itself in a satisfactory manner and that there has not been any major change in recent years, although there has recently been a minor downswing in abundance.

The importance of maintaining the present system of party boat reporting on a permanent, long-range basis cannot be too strongly emphasized. It is fortunately not unduly expensive or time consuming. As new hazards to the striped bass arise from further industrialization of the San Francisco Bay area and increasing manipulation of the waters in which the fish spawn, it will become more and more important to know what is actually happening to the population.

MANAGEMENT OF THE STRIPED BASS FISHERY

It goes almost without saying that the purpose behind these catch records and the other phases of the California Division of Fish and Game's striped bass studies is to obtain reliable information on which to base a sound management and conservation program. Certain conclusions of practical importance are already beginning to emerge. Perhaps the most significant is that the striped bass are not being over fished. It will be recalled that the party boat records and the postal card surveys both indicated a slight downward trend in abundance since 1944. But what has caused this decline?

It is important first of all to learn if it occurred because we have been catching too many striped bass each year and depleting the species. Three separate lines of evidence indicate that this was not the reason. Perhaps the most convincing is the fact that the decline in abundance coincided with a decline in fishing. The reverse should have occurred if fishing had

caused the decline. We do not yet have reliable estimates of the amount of fishing for striped bass which goes on each year, but it is fairly certain that it declined appreciably during the war. It certainly did not increase. As can be seen from the figures in Table 14, four different types of

TABLE 14

Summary of Available Statistics Indicative of the Extent of Striped Bass Angling During the War

Year	California angling licenses issued	Trend of number of successful striped bass anglers*	Number of party boat permits issued in San Francisco Office	Number of party boat logs received (striped bass only)
1936	298,736	94		
1937	312,969	92		
1938	346,661	104		1,984
1939	366,452	100		2,834
1940	388,472			3,925
1941	453,159	118	321	3,969
1942	433,431	99	154	1,629
1943	445,416	84	130	1,361
1944	436,940		118	860
1945	554,027		214	1,869
1946	766,753	125	268	2,736
1947	884,700		296	3,487
1948	† 957,000		345	3,053

* From postal-card surveys. Expressed as percentage of the 1939 (median) figure. The absolute value of the estimates has never been adequately checked, and they are valuable only to indicate trends.

† Tentative figure. Final total not yet available.

statistics which ought to be indicative in a general way of the amount of striped bass fishing going on each year remained at about the same level or declined somewhat during the war. Had a significant increase in fishing taken place, it should have been reflected by a rise in some or all of these figures. Further confirmation derives from close personal contact with the livery boat fishery in early 1946. At that time the boat-rental establishments were obviously recovering from a wartime slump. Wartime reductions in recreational travel, gasoline consumption, and leisure time apparently more than counterbalanced the effect of the influx of newcomers to the Bay area during the war. Opinions of party boat operators and sportsmen who have been questioned on the matter are in full agreement.

The second reason for believing that fishing pressure on striped bass is not excessive is based on the well-established fact that heavily fished populations contain relatively few large, old individuals, most of the catch consisting of small, young fish. This is particularly applicable to a long-lived species such as the striped bass. It is readily demonstrable that a considerable part of the California striped bass catch consists of medium and large fish, and this would almost certainly not be the case if they were being heavily overfished. Table 15 summarizes length measurements of 9,443 striped bass caught by anglers during 1946 and 1947. A sizable proportion of these fish were more than 19 inches long, and there were fair numbers more than 28.5 inches long. While this series of length measurements is not a representative sample of the catch as a whole, it is extensive enough to be very meaningful. It bears out the

impression one gets from the weight charts in preceding sections that the larger size groups of striped bass are fairly abundant. Even more important, there is no indication in the weight charts of any major decrease in the relative numbers of the larger fish during the past 11 years.

Nineteen inches is a rough dividing line between immature females and mature females capable of spawning (Scofield 1931). Many males begin to spawn when they are 12 inches long. It is a safe conclusion that there will be adequate numbers of spawners as long as the situation portrayed in Table 15 continues. The tremendous reproduction potential of the species was demonstrated by the speed with which the population built up in California after the original introduction.

TABLE 15

Summary of Striped Bass Length Measurements

Source of sample	Place caught	Date	Total number measured	Under 19 inches*	19 to 28.5 inches*	Over 28.5 inches*
Season catch on two party boats, measured by the operators	Block 308	June 1 to November 15, 1947	6,688	58.5%	37.9%	3.6%
Creel checks of livery boat anglers	Block 303	Winter and spring, 1946 and 1947	2,291	22.3%	54.2%	23.5%
Creel checks of livery boat anglers	Block 301	Summer and fall, 1946	323	36.5%	60.9%	2.5%

* Measured from tip of lower jaw to fork of tail.

The notable cooperation of Messrs. Wm. Rowland and Wm. Esmond, who measured almost all the fish caught on their party boats during the 1947 season, is worthy of special mention.

The third and final line of evidence is weakest of all at the present time, but it should eventually become the most important. Limited numbers of striped bass have recently been tagged with disc tags [1] and rates of return have been rather low. From the first group of 242 fish tagged in the San Joaquin Delta in January of 1947 only 18 tags (7.4 percent) were returned within a year, which is about as long as tags of this type can be expected to remain on the fish. These were all large fish, averaging 29 inches in length.[2] A comparable rate of return occurred in a similar but smaller group of fish tagged at the same place about ten months later. The returns from the two groups are outlined in the first and second columns of Table 16.

[1] These tags are described by Merriman (1941). They consist of two celluloid discs one-half inch in diameter, held in place by a metal pin through the back of the fish.

[2] This and all other length measurements cited are from the tip of the lower jaw to the fork of the tail.

TABLE 16

Recovery Rates of Tagged Striped Bass

	First group	Second group	Third group
Tagging locality	Franks Tract Block 303	Franks Tract Block 303	Napa River above Vallejo Block 308
Date tagged	January, 1947	November, 1947	October and November, 1947
Number tagged	242	94	336
Length*: Average (inches)	29.1	32.3	9.7
Range	20 to 37	26 to 37	8 to 24
Standard deviation	3.2	1.9	0.9
Tag returns within 6 months	12	2	27
Annual rate of recapture on basis of 6-month returns	10%	4.3%	16%
Tag returns within 1 year	18	5	54
Annual rate of recapture on basis of 12-month returns	7.4%	5.3%	16.0%

* Tip of lower jaw to fork of tail.

Another group of 336 small fish averaging 9.7 inches long was tagged in the Napa River in the autumn of 1947. Sixteen percent of the tags were returned within a year. This is not an excessively high rate of return. Much higher rates have been obtained on the Atlantic Coast. Vladykov and Wallace (1938) got 632 (42.4 percent) returns of tags within nine months from 1,563 striped bass tagged in Chesapeake Bay and returns up to 90 percent are reported from there (Tiller 1944.) Merriman (1941) obtained 33 percent returns from one group of 303 fish and 24 percent returns from another group of 1,397 fish. Similar tags were used in all of this work, so results are reasonably comparable from that standpoint. Apparently fishing pressure is appreciably higher on the Atlantic Coast, where commercial fishing is permitted, than it is in California, where the species is reserved for the angler.

The only previous tagging of striped bass in California was done by Clark (1936) in the early 1930's. Most of these fish were less than 13 inches long. He obtained recoveries ranging from 9 to 17 percent in different years from a total of 1,544 bass tagged.

It has not yet been possible to tag a sizable number of medium-sized striped bass in California. Until this is done it will be hazardous to generalize very broadly about over-all fishing pressure on the basis of tag returns. The medium sizes are the backbone of the fishery and it is quite possible that they are fished more heavily than the very large or very small ones, which have been tagged so far. Meanwhile, it is safe to say that there is certainly nothing in the results of any of the tagging experiments already conducted to indicate excessive fishing pressure on California striped bass, even allowing for some shedding of tags and failure of anglers to return tags to us.

The three lines of evidence taken together are convincing, and for the time being it will be wise to base management policies for the striped bass fishery on the assumption that the species is not being fished too heavily and that any slight decline in abundance which may have occurred in recent years had other causes than overfishing.

The most obvious and most important corollary is that any thought of reducing fishing pressure by restrictive measures such as closed seasons, decreased bag limits, or increased size limits should be abandoned for the time being. It must be emphasized, however, that this policy may require revision at some future date. There is still a lot to learn about the bass, and conditions are changing. We should therefore keep an open mind in this connection. It is particularly important to remember at a time when angling pressure is increasing very rapidly, that laws and regulations which restrict angling unnecessarily are highly undesirable. It must be our objective to realize the maximum recreational value from our sport fisheries consistent with the welfare of the fish populations involved. In other words, we must try to derive as many days of angling as possible without depleting the striped bass.

It might be well to point out that the recently imposed bag limit of 25 pounds and one fish, in addition to the five-fish limit already in force, was a special measure with a special purpose, and should be retained. It was designed to cut down on the terrific slaughter of large fish which occurs at certain times, when virtually every angler takes limits of big fish. When this occurs now the anglers take only two or three large fish, which is plenty, instead of the former five, which was wasteful.

Let there be no misinterpretation on the part of those who might wish to jump from the statements that have just been made to the conclusion that a resumption of commercial fishing for striped bass in California might be justified, for such is not the case. It does not follow that we are underfishing, because we are not overfishing. Commercial exploitation of striped bass in California is unthinkable because of the unusual nature and location of the fishery. Its recreational value is so tremendous that commercial fishing would be wasteful. The unlimited recreation provided at the doorstep of a great metropolitan area is an asset upon which it is difficult to place a monetary value, but it is certainly a very great asset which should be utilized to the fullest possible extent.

Further industrialization of the San Francisco Bay area, coupled with increased diversion and manipulation of the up-river waters in which the striped bass spawn, promises to present increasing problems in the way of maintaining the species at a high level of abundance in the future. An ever-increasing angling pressure is also to be expected, and the increase will probably be rapid in the immediate future, as the great numbers of newcomers to the Bay area learn the fairly complicated art of striped bass fishing. Let us be thankful that we have in the striped bass a fish which appears to be holding its own under the strain, and let us protect it from pollution of its habitat and diversions in its spawning grounds. Such things, in the final analysis, present the real long-range threat to the striped bass, for they can permanently reduce their abundance, whereas overfishing could at most only reduce it temporarily. As a matter of fact, the most serious threat of all, which is looming in the future, is the possibility that it may eventually become economically feasible to construct a salt-water barrier across the mouth of the Sacramento River system, as contemplated by the Reber Plan (Wright 1948). It is difficult to predict what could be done to save the striped bass in such an event, but the outlook is not promising.

SUMMARY

A system of catch reporting by individuals taking parties of anglers fishing for striped bass has been in operation in California since 1938. Monthly averages of daily catch per angler and average weight of striped bass caught have been calculated from their reports. These averages have been charted in checker diagrams which summarize 11 years of reports for each of six fishing regions. Most of the regions exhibit characteristic seasonal patterns of fishing quality and average weight of striped bass, repeated year after year.

The party boat records indicate that the California striped bass population is maintaining itself satisfactorily, although there has recently been a minor decline in abundance. This is confirmed by other records. The decline did not result from over-fishing, judging from the available evidence, which is convincing. It is believed to represent a normal fluctuation in abundance of a sort to be expected from time to time.

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THE WARM-WATER GAME FISHES OF CALIFORNIA[1]

By Brian Curtis[2]

When Nature was handing out her gifts so generously to California she was guilty of one oversight: she left a serious scarcity of game fishes in the warmer inland waters of the State. The salmon swarmed through San Francisco Bay and the Delta to their spawning grounds in the cooler tributaries above, and the steelhead swam up the coastal streams to lay their eggs and return to the sea. But when the first white man came there was only one game fish which resided permanently in the warm inland waters—the Sacramento perch, confined mostly to the Sacramento-San Joaquin River system. The striped bass, the black basses, the sunfishes, the catfishes, which are now so widespread and furnish so much fishing, are not native sons; they have been brought by man from east of the Rockies since 1870.

The purpose of this article is to tell something of the habits and the geographical range of these fishes, and to enable anglers and others to identify them. It is based to some extent on original observation and experience, but also draws on the published work of others (see "References" at end). In its preparation, valuable technical advice has been received from several members of the Bureau of Fish Conservation of the California State Division of Fish and Game, particularly from William A. Dill, Chester A. Woodhull, and Garth I. Murphy; and valuable suggestions from Dr. R. W. Eschmeyer of the Tennessee Valley Authority.

[1] Submitted for publication July, 1949.

[2] Formerly of the Bureau of Fish Conservation, California Division of Fish and Game.

The 17 species to be dealt with here belong to four families, as follows:

Catfish Family (Ameiuridae)

Channel catfish, *Ictalurus lacustris*
White catfish, *Ictalurus catus*
Yellow bullhead, *Ameiurus natalis*
Brown bullhead, *Ameiurus nebulosus*
Black bullhead, *Ameiurus melas*

Perch Family (Percidae)

Yellow perch, *Perca flavescens*

Sunfish Family (Centrarchidae)

Smallmouth black bass, *Micropterus dolomieu*
Spotted black bass, *Micropterus punctulatus*
Largemouth black bass, *Micropterus salmoides*
Green sunfish, *Lepomis cyanellus*
Bluegill, *Lepomis macrochirus*
Pumpkinseed, *Lepomis gibbosus*
Sacramento perch, *Archoplites interruptus*
Warmouth, *Chaenobryttus coronarius*
White crappie, *Pomoxis annularis*
Black crappie, *Pomoxis nigro-maculatus*

Bass Family (Serranidae)

Striped bass, *Roccus saxatilis*

The names used here are taken from the list recently published by a committee of the American Fisheries Society in an effort to establish, among other things, common names which would henceforth be used throughout the country for each kind of fish (black crappies, for instance, have in the past been called "calico bass" in some regions; bluegill and green sunfish, "perch" and "bream"). The scientific names in our list have not been carried down to sub-species; there is too little certainty as to exactly which ones are present here. The placing of black bass in the sunfish family and of striped bass in the bass family may appear strange, but it is an accepted fact that the former belong in the Centrarchidae and the latter in the Serranidae (formerly called "Sea bass family," a term now reserved for another group which includes the purely marine forms such as the groupers.)

The list above is arranged in what might be called natural order: the species which are most primitive from the evolutionary viewpoint come first, and the most advanced, which are also the most specialized, last. For purpose of identification it is more convenient to group them according to conspicuous features of their anatomy, regardless of their genealogical relationships. This is done in the key on page 257. Color is used as little as possible because the variations between individuals of the same species make it an unreliable distinguishing characteristic.

It should be noted that no single feature should be relied on for identification; it is the combination which gives the answer. For instance, lack of scales occurs not only in the catfishes, but also in the sculpins (Cottidae) which are not treated here; but the adipose fin is not present

in the latter. On the other hand, all the trout and salmon are like the catfish in having adipose fins, but they have scales whereas the catfish do not.

It must be remembered that the key will not work on marine species, nor on fishes not now occurring in California. Further information on relatives of many of our warm-water fishes may be found in "Fishes of the Great Lakes Region" by Hubbs and Lagler (1947). And for identification of many of our fresh-water fishes which are not included here use can be made of "A key to the fishes of the Sacramento-San Joaquin Basin" by Murphy (1941).

Only the simplest, most easily discernible features are given in our key. They may not always suffice to distinguish between closely related species. In such cases, further reference should be made to the characters described in the text treatment of the various fishes.

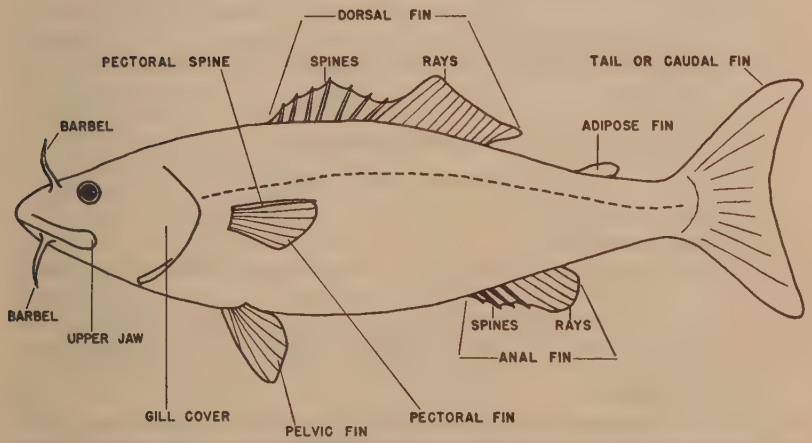

FIGURE 73—Diagram of composite fish, showing anatomical features used in the key. Note that no fish combines all the features shown above

ARTIFICIAL KEY TO THE WARM-WATER GAME FISHES OF INLAND CALIFORNIA

(Based on Features Which Will Distinguish These Species From All Other California Fresh-water Fishes) [3]

1a. SKIN WITHOUT SCALES. Adipose fin present. Barbels ("whiskers") around mouth.

2a. Tail fin forked or deeply concave.

3a. Upper lobe of tail fin slightly longer than lower. Rays in anal fin 19 to 21.

WHITE CATFISH, *Ictalurus catus*

[3] Colored plates of the principal species are included at the end of this article. The author is indebted to the Illinois Natural History Survey for permission to reprint Plates 1-4 and 7-10, which originally appeared in Forbes and Richardson's *The Fishes of Illinois*. Plate 5 is from a color photo by Chester Woodhull. Plate 6 originally appeared in *California Fish and Game*, Vol. 34, No. 4.

3b. Two lobes of tail fin of equal length. Rays in anal fin 25 to 29. Body often spotted, especially in young.
CHANNEL CATFISH, *Ictalurus lacustris* (Plate 8 *)

2b. Tail fin square or rounded or slightly concave.
4a. Chin barbels whitish. Rays in anal fin 24 to 27. Tail rounded.
YELLOW BULLHEAD, *Ameiurus natalis* (Plate 9)

4b. Chin barbels gray to black. Rays in anal fin 17 to 24. Tail square-cut.
5a. Fin rays and membranes of same color. Pectoral fin spines usually carrying strong barbs on posterior edges.
BROWN BULLHEAD, *Ameiurus nebulosus*

5b. Fins generally with jet black membranes. Pectoral fin spines without strong barbs on posterior edges.
BLACK BULLHEAD, *Ameiurus melas* (Plate 10)

1b. SKIN WITH SCALES. No adipose fin. No barbels ("whiskers"). Dorsal fin of two parts, the forward of spines, the posterior of soft rays.
6a. Spinous and rayed parts of dorsal fin completely separate.
7a. Narrow, dark longitudinal stripes along side of body, 7 or 8 in number.
STRIPED BASS, *Roccus saxatilis* (Plate 6)

7b. Body dark olive above, sides golden yellow; dark bands or bars, 6 or more in number, extending from the back down the sides across the lateral line toward the belly.
YELLOW PERCH, *Perca flavescens*

6b. Spinous and rayed parts of dorsal fin joined together.
8a. Dorsal spines 12 or 13.
SACRAMENTO PERCH, *Archoplites interruptus* (Plate 5)

8b. Dorsal spines 5 to 11.
9a. Anal spines 5 to 7.
10a. Dorsal spines 6 (rarely 5 or 7). Body with dark vertical bars, or plain silvery.
WHITE CRAPPIE, *Pomoxis annularis*

10b. Dorsal spines 7 or 8 (rarely 6, 9, or 10). Body with dark mottling.
BLACK CRAPPIE, *Pomoxis nigro-maculatus* (Plate 7)

9b. Anal spines 3.
11a. Body bass-shaped, length from snout to base of tail fin more than three times the depth. Scales small, 58 or more along lateral line.
12a. Mouth large, usually reaching back behind the eye in adults. Deep notch between spinous and rayed parts of dorsal fin. No scales on anal and dorsal fin membranes.
LARGEMOUTH BLACK BASS, *Micropterus salmoides* (Plate 1)

12b. Mouth small, not reaching back behind the eye. Dorsal fin not deeply notched as in largemouth. Anal and rayed dorsal fin membranes with scales near base.
13a. Scales in lengthwise series 70 to 80. Sides plain or showing vertical bars.
SMALLMOUTH BLACK BASS, *Micropterus dolomieu* (Plate 2)

13b. Scales in lengthwise series 60 to 68. Sides with spots and blotches which tend to form an irregular longitudinal stripe.
SPOTTED BLACK BASS, *Micropterus punctulatus*

* The scientific name *Ictalurus punctatus* inadvertently appears on Plate 8. The correct current usage is *Ictalurus lacustris*.

11b. Body sunfish-shaped, length from snout to base of tail fin less than three times depth. Scales large, 53 or fewer along lateral line.

14a. Teeth present on tongue. Eye red.

WARMOUTH, *Chaenobryttus coronarius*

14b. No teeth on tongue.

15a. Pectoral fins short and rounded. Upper jaw reaching back nearly to middle of eye or even beyond.

GREEN SUNFISH, *Lepomis cyanellus* (Plate 4)

15b. Pectoral fins long and pointed. Upper jaw not reaching back nearly to middle of eye.

16a. Black spot on gill cover not bordered by red; rear margin of gill cover flexible.

BLUEGILL, *Lepomis macrochirus* (Plate 3)

16b. Black spot on gill cover bordered posteriorly by red; rear margin of gill cover stiff.

PUMPKINSEED, *Lepomis gibbosus*

The fresh-water viviparous perch is sometimes taken by anglers, although not generally considered a game fish, and might be confused with members of the sunfish family. However, it rarely reaches more than five inches in length, and has 17 dorsal spines (rarely 16 or 18), whereas none of our sunfishes has more than 13. It is of interest in that it brings forth its young alive. The family to which it belongs, the Embiotocidae, has many species which live in the ocean, but this is the only fresh-water representative.

Two other kinds of fish which might confuse anglers, encountered not only in warm waters but even sometimes in company with trout, are the carp and the goldfish, both imported from Asia via Europe. Both have single dorsal fins composed of soft rays one of which is modified to form a strong, barbed spine; and a similar spinous ray occurs in the anal. The carp have barbels above the mouth, something like the catfishes, and some individuals have no scales; but all lack the adipose fin. The goldfish all have scales, but no barbels and no adipose fin; in the wild state they may revert to a grey or green color, although some retain the gold. Carp reach a large size, two-foot individuals not being unusual. They are considered good food in parts of Europe and North America, and even good sport in some regions, but have never found favor from either point of view in California. They are recognized as undesirable associates for our game fishes. As for goldfish, no one can be found to say a good word for them except for ornamental purposes.

The species listed on page 256 comprise all members of the four families under discussion here which are now known to be present in California. Certain fishes listed in earlier publications are not included because, from the best information available, they are no longer present. The rock bass, for instance, *Ambloplites rupestris*, supposed to have been first introduced into Napa Creek in 1874 (Evermann and Clark, 1931), has furnished no authentic record of its presence in the State for many years. Certain other species which did not appear in earlier lists are given here because they are known from authentic records to be now present in the State. Dates of introduction in the pages which follow are sometimes at variance with former published reports. They are based on the latest knowledge, and are subject to revision. A study is now being

made of the records on this subject which will, it is hoped, give final determinations, insofar as such things can ever be final, and the results will be published in a paper by another author.

SUNFISH FAMILY (CENTRARCHIDAE)

These fishes are native solely to North America, all east of the Rockies except the Sacramento perch. They are primarily warm-water fishes, and furnish the bulk of the sport fishing throughout a large part of the United States.

The Black Basses

The black basses originally lived in the Great Lakes, the Mississippi Valley, and the eastern coastal plain from northeastern Mexico to North Carolina. For many years there were thought to be only two species, the largemouth and the smallmouth. Now a third is recognized, the spotted or Kentucky black bass, intermediate between the other two in mode of life and in habitat preference. It does not get as large as either of the others, rarely exceeding three pounds, but it is considered a first-class game fish. It was brought into California in 1933 by air. It has been raised at the Central Valleys State Fish Hatchery, and planted in scattered lakes and ponds, but it is doubtful that it has become established in natural waters, except possibly in the Cosumnes River.

The largemouth and smallmouth were first brought into the State together in 1874 and placed in Napa River and in Alameda Creek. The smallmouth has since spread rather spottily through the central and northern parts of the State, and is found, among other places, in Putah Creek (our best-known smallmouth stream), the Russian River, Stony Gorge Reservoir in Glenn County and the creek above, and in the lower parts of the Feather, American, Tuolumne, Stanislaus, Merced, San Joaquin, Kings, and Kern Rivers. Because of its more exacting needs it is less numerous and less widely distributed than the largemouth, which is common throughout the Sacramento-San Joaquin system and reaches its greatest abundance in the warm waters of Southern California.

Preliminary estimates based on reports from anglers to the California Division of Fish and Game (Curtis, 1940) indicate that in 1948 some 128,000 licensees, representing 13 percent of all anglers, caught 1,890,000 black bass, of which 27 percent were taken in San Diego County, 8 percent in San Bernardino County, and 5 percent each in Los Angeles, Imperial, and Riverside Counties. In all, over 50 percent of the whole catch came from south of the Tehachapi. Lake and Fresno, each with 5 percent, were the leading counties north of this point.

The features given in the key will not always serve to distinguish the black bass species, especially when very young fish are in question. In the young smallmouth there is a distinct black band across the tail fin; this is less distinct in the spotted, and may be either present or absent in the largemouth. It disappears as the fish grow. The young smallmouth often have dark vertical bars on the side; these are lacking in the largemouth and the spotted, which usually have a dark longitudinal streak. An infallible characteristic at all ages, although not an easy one for the inexperienced to recognize, is found in the pyloric caeca, the finger-like

appendages of the intestine. These are, in the largemouth, mostly branched; in the smallmouth unbranched or with at most only one or two branched.

While both are essentially warm-water fishes, the smallmouth can flourish at lower temperatures than the largemouth, which is at its best in waters which reach at least 80 degrees for several months of the year. It lives in lakes, ponds, and deep, slow-flowing channels, whereas the smallmouth can stand a swifter current. The latter does best in clear, boulder-strewn streams with large pools, and in clear lakes with scanty vegetation and shoal areas of rock or gravel for spawning; it needs moderate summer temperatures, neither very cold nor excessively warm.

The smallmouth is often called a gamer fish than the largemouth. Both species are taken by casting with various lures, by still-fishing with minnows or bait, and by trolling. The largemouth can be taken on a fly, but the smallmouth is much more often sought in this manner.

Largemouth grow bigger than smallmouth, the former having been known to reach a weight of 22 pounds against 14 for the latter. This is in the south, where warm temperatures make for rapid growth. In the northern division of the 1947 Field and Stream contest, the national largemouth winner came from Blue Lake in Lake County, California, and weighed 11 pounds and 13 ounces. In general, weights of five pounds for the largemouth and three pounds for the smallmouth are considered highly satisfactory by anglers. Both species are good eating.

The young of both live on minute crustaceans such as copepods and "water fleas," and as they grow older on insects and larvae and then small fish. The adults eat larger food, such as big fish and crayfish; the presence of the latter in greater numbers in the stomachs of smallmouth than of largemouth is perhaps more a matter of habitat than of diet preference, since crayfish are more abundant in the waters preferred by the smallmouth.

Both species have a tendency to become lethargic, with loss of appetite, when the water grows colder than 50 degrees, and to "hibernate" in deep water in winter. As the temperature rises in the spring, they move into the shallows, and when the water advances above 60 degrees they prepare to spawn—earlier in the season, in any given locality, than the other members of the sunfish family.

The spawning of the two species is very similar except for the type of bottom used. The smallmouth wants gravel, rubble, coarse sand, bedrock or a combination; the largemouth is not so choosy, and can do with almost any kind of bottom provided it can clear away mud or sediment to reach some hard surface such as roots or twigs to which its eggs can adhere.

The spawning pattern is similar, except for differences in detail, in most members of the sunfish family. That of the smallmouth will be described here as typical (Hubbs and Bailey, 1938). The male does most of the work. In water from three to six feet deep (extremes of 10 inches and 12 feet have been observed) he "takes up territory"—a small area which he looks upon as his own, and from which he unhesitatingly drives out all other fish. Choosing a spot within this territory, often near a boulder or stump which gives protection on at least one side, he sets to work to clear it of silt, sediment, and rubbish. For this he uses principally fin and body movements which sweep clear a circle of

diameter about twice his length; but he may at times pick up objects in his mouth and carry them out to the edge of the circle. He may spend anywhere from four to forty hours at this task, or even longer if a drop in temperature causes him to cease work temporarily. The end result is a nest or "redd" from which all the fine material has been removed—a saucer-shaped depression which is conspicuous because of its brightly polished bottom.

Here the male remains until a female approaches. After a courtship which varies in length and elaborateness with the individuality of the mates (and in some of the sunfishes is much more complicated than in the black basses) the female swims over the nest and, with her vibrating body heeled over at an angle of about 45 degrees, emits a few dozen eggs. The male, with his body vertical and touching hers, emits milt at the same time. The eggs settle and adhere immediately to the clean stones below. After several such periods of egg-laying, separated by short rest intervals, the female departs. It is probable that all of her eggs do not ripen at once, and that she spawns again, two or even three times, often with different males. The male, on the other hand, may still contain milt, or may ripen an additional quantity, and spawn again with a second or third mate. A two-pound female contains about 6,000 eggs, and even though these are not deposited all at one time, the successive marriages build up quite a family (Curtis, 1949). Ten thousand eggs in one nest is not unusual.

The development of the eggs is dependent on temperature; indeed, a sudden cold spell may kill them. Under normal conditions, hatching time is short: Two days at 72 degrees, five days at 66 degrees. During this period the male remains on guard, driving off all hungry intruders, and fanning the nest gently with his fins to keep it free of fungus, parasites, and microscopic predators. He does not feed, but may attack an angler's lure under the impression that it is an enemy. The still unsettled controversy over whether he takes it into his mouth or merely butts it with his snout, whether he is easy or hard to capture when guarding his nest, has a bearing on the need for a closed season at spawning time; but that bass have at times been taken off their nests by anglers is a matter of record. When this happens, or even when the guarding parent is scared away for a short interval by an angler's boat, other fish may rush in and feast on the eggs.

As the young fish hatch they fall into the crevices between the stones in the bottom of the redd where they lie for a while until they are able to swim. When they rise in a swarm from the nest the male continues to guard them, circling around and keeping them together for a varying number of days, depending on the individual. Eventually, however, a time comes when his ideas change. He ceases to regard his offspring with affection. They become just ordinary little fish, and all little fish are good to eat, and unless they forthwith strike out on their own they go down his throat.

Growth in young bass, as in all fish, depends on temperature: the warmer it is, the harder the digestion works, the more they eat, and the faster they grow. Largemouth tend to inhabit warmer waters than smallmouth and to grow faster. By autumn they are from two to seven or eight inches long, and within a year the more precocious ones may attain

ten inches in length, but it is the end of the second year before most of them have reached the 8- to 12-inch range. Under highly favorable conditions they may mature and spawn at the end of the first year, but more often it is at the end of the second, and sometimes of the third.

The Sunfishes Proper

Those members of the sunfish family which are properly called sunfishes (although the terms bream and fresh-water perch are used in some parts of the country) tend to be rounded rather than elongated when viewed from the side. The depth is greater in proportion to the length than in the conventional fish.

Of the three species now present in California one, the pumpkinseed, is so rare that it can for all practical purposes be disregarded. The bluegill and the green are quite similar in appearance, but the bluegill is rounder in outline, being deeper in proportion to length than the green, and has a distinctly smaller mouth than the latter. It is more prickly to the touch, in the adult sizes, than the green.

The green sunfish was first brought into California in 1891 from Illinois and placed in Lake Cuyamaca in San Diego County. The bluegill may have come at that time also, but the first unequivocal reports date from 1908. Both species have been planted throughout the State, but the bluegill now has wider distribution. It is found in almost all lakes and slow-flowing streams with warm summer temperatures. It is also unfortunately present in some of the cooler waters, where it does not do well. The green sunfish, while far less abundant, does occur in many bluegill waters, and may also be associated with trout, as in Lakes Pillsbury and Arrowhead, and in the Eel and Klamath Rivers (the bluegill is also present in the last-named). It is a more frequent associate of the smallmouth bass than is the bluegill; it likes rocky places, and adapts itself better to stream life. Both occur in the Colorado River.

In the catch estimates for 1948, 118,000 anglers, representing 12 percent of all California licensees, caught 4,800,000 sunfish, of which over 65 percent were taken south of the Tehachapi (San Diego County 39 percent, San Bernardino 10 percent, Los Angeles 8 percent, Orange 4 percent, Imperial 4 percent). Further north, the leading county was Lake, with 4 percent of the total catch. Both species are caught on bait and spinners, and furnish excellent sport on a light fly rod with a small wet fly. Bluegill as heavy as two and one-half pounds have been caught, although a half-pounder is considered a very respectable fish. In some over-populated waters they become stunted, and rarely reach four inches in length. The green sunfish is quite consistently smaller in California waters than the bluegill. Both are excellent eating; the bluegill in particular is unsurpassed, its meat being sweet, firm but delicate, and not too oily.

They spawn later in the year than do the black basses, not starting much before water temperatures cross 75 degrees. Their season, however, lasts longer—into late summer—with repeated spawnings of the same individuals, and resulting enormous crops of young of all sizes.

They often place their nests in close proximity, forming almost a continuous pavement over a wide area of the bottom. Aside from details, their courtship, spawning, and care of young are very similar to that of the black bass (Breder, 1936). The bluegill and the green sunfish often hybridize in nature. These crosses are always sterile, and are from 81 to 95 percent males.

Of the pumpkinseed there were until 1948 only two authentic records in the State, one from near Mecca, Riverside County, in 1939 and one from Modoc County in 1946. Of how these specimens came to be in such widely separated spots, nothing is known. A further importation occurred in 1948, when a number were furnished by the U. S. Fish and Wildlife Service for planting by the owners in Irvine Lake, Orange County.

The Crappies

Both black and white crappie came from Illinois in 1891 to Lake Cuyamaca in Southern California. Subsequent introductions occurred later into various parts of the State. The white has survived only in the San Diego area, where it sometimes outnumbers the black, and in the Colorado River drainage. Its origin in the latter is unknown. The black crappie, otherwise known as "calico bass," is widespread, and in some waters is the mainstay of the catch. In 1948, according to the estimates, 100,000 anglers caught nearly 3,000,000 crappies, of which some 80 percent came from Southern California (San Diego County 54 percent, San Bernardino 14 percent, Orange 5 percent, Los Angeles 4 percent). The white crappie is more at home in turbid waters than the black, and is not averse to a mud bottom. Both do well in warm sloughs, lakes, reservoirs, and large, slow rivers. They compete with bass for food, and often become more abundant than the latter where both are present in the same lake.

While the two are very similar in appearance, the black crappie only is present in most parts of the State and there is no chance for confusion. In the Colorado River and around San Diego, where both occur, the general shape (the black has a more highly arched back) and the color pattern (the white is more apt to have dark vertical bars on the side) serve as a guide to the angler who has become familiar with both. The best single anatomical feature for telling the two apart—since the numbers of spines in the dorsal fin are variable and sometimes overlap—is the length of the *base* of the dorsal fin (Dill, 1944). In the black crappie this is about equal to the distance from the forward end of the dorsal fin to the eye; in the white, much less than the distance from the forward end of the dorsal fin to the eye.

Worms, spinners and plugs are used to capture these fish, but a live minnow is the best bait. Both species put up a good fight; the black is considered slightly sportier. They are apt to gather in numbers in the shelter of submerged stumps or brush-heaps. They sometimes exceed three pounds in weight, but one pound is much commoner. Both are good eating.

Both spawn from May to July at temperature ranges of 64 to 68 degrees. They make circular nests somewhat similar to the black basses, but generally in deeper water and where there are roots or leaves to which the eggs can adhere. The white has been known to attach its eggs to dense growths of algae.

The young eat largely plankton at first, and small aquatic insects and larvae. They quickly move into open water, and graduate to a fish diet, which is the staple of the adults.

Sacramento Perch

This only member of the sunfish family native to California was extraordinarily numerous here in early days. It has declined greatly in numbers—a fact presumably connected in some way with the importation of exotic species—and, while it can not be called rare, now plays a minor part in the sport fishery. It was originally abundant in all the sloughs and slow-flowing channels of the Sacramento-San Joaquin system, and in the Pajaro and Salinas Rivers as well; now it is not often seen except in a few places, such as Clear Lake, where it has managed to maintain significant numbers.

Still-fishing with worms or live minnows is the standard method of capture, but it can be caught casting with a spinner. It has been known to reach a length of 24 inches, but individuals over 12 inches are rare. For edibility, it ranks among the best.

The only published record of its spawning is that of Murphy (1948). In Clear Lake, Lake County, on June 15, 1947, in water of 75 degrees temperature, he observed a group of about 50 spawning near a rock breakwater in one to two feet of water. Contrary to the usual practice in the sunfish family, there was no nest-building and no guarding. While all the fish were concentrated in an area about 12 by 4 feet, floored with boulders covered with algae, each pair spawned in a definite space about one and one-half feet in diameter; there appeared to be some exchange of mates between pairs. Spawning activity lasted about six hours, during which eggs were deposited in great abundance (84,000 eggs have been found in a single 10½-inch female), and adhered to the algae on the rocks; thereafter the fish wandered away. On the following day a search revealed that very few eggs remained, and it may be assumed that they had been eaten by other fishes. Murphy advances the hypothesis that we may have here the explanation of the depletion of the Sacramento perch population: that originally there were no species of fish in their native waters which habitually attacked their unguarded nests, but that the introduced sunfishes, catfishes and carp have feasted on their exposed eggs until very few remain.

In Clear Lake Sacramento perch reach a length of 3½ inches (about one-half ounce in weight) at the end of the first year; seven inches (3½ ounces) at the end of the second; eight inches (six ounces) at the end of the third; and nine inches (eight ounces) at the end of the fourth. They start spawning at the beginning of their second year.

Warmouth

According to the records (Evermann and Clark, 1931) the warmouth came first to California in 1891, when 400 were placed in Lake Cuyamaca and 100 in the Feather River near Gridley. There are none

now in Lake Cuyamaca, although they may be present in other parts of Southern California. In the Central Valleys they are fairly numerous, being especially abundant in muddy areas. They are an excellent small game fish, though little known to our anglers and presumably lumped with the bluegill and green sunfish in our catch records. The teeth on the tongue serve to distinguish the warmouth from these two species when the fish are in hand.

The warmouth is most at home in medium to shallow waters, and does better in ponds than in streams. It spawns in the spring in the usual manner of its family. It rarely reaches more than 10 inches in length. It eats insects, crustaceans, and small fish, and is taken on bait, flies, and small artificial lures. It is good eating.

BASS FAMILY (SERRANIDAE)

Striped Bass

The striped bass is native to the Atlantic coast from the St. Lawrence River to the Gulf of Mexico, and the history of its introduction into California is one of the outstanding examples of successful importation of exotic species. Two small shipments of young fish were made from New Jersey, one of about 135 specimens in 1879 and the other of about 300 in 1882, both to the Sacramento River in the neighborhood of Martinez. From these few individuals has come the enormous population of striped bass which, with its center in San Francisco Bay and the Delta, has spread up and down the coast for hundreds of miles, with extreme stragglers found in the ocean off San Diego and at the mouth of the Columbia River. And, although the fish has been a favorite of sport and commercial fishermen along the Atlantic seaboard for years, it is probable that the concentration of fish and fishermen in the Sacramento-San Joaquin Rivers exceeds anything on the east coast. The effort which was made in 1929 and 1930 to establish this species in the Salton Sea was a failure, in spite of early reports to the contrary. It is now definite that none of the transplants of nearly 7,000 fish survived.

Commercial fishing for striped bass was abolished in California in 1935. Since then, the numbers taken by sport fishermen have exceeded the highest catches ever made for market. It is estimated that in 1948 160,000 anglers, or about 16 percent of all fishermen, fished successfully at one time or another for striped bass, and captured over 1,650,000, of which 32 percent came from the waters of Contra Costa County, 13 percent from Solano, 12 percent from San Joaquin, and 12 percent from Sacramento. Some fish are caught in the surf, but as can be seen the majority are taken inside the Golden Gate.

Trolling and surf-casting are both successful fishing methods, but the greatest part of the catch is made still fishing, with sardines, fresh or frozen, almost universally used for bait. However, tastes differ, and one angler swears to having caught striped bass with a raw tomato on the end of his line.

This fish has been known to reach a length of six feet and a weight of 125 pounds. In the California sport fishery 20-pounders, while not uncommon, are regarded with pride, and it is estimated that the average of all fish taken by anglers is probably in the neighborhood of four

pounds. Eating qualities are excellent, and the flesh can be kippered to form a delicious appetizer.

While it spends part of its time in fresh water and part in salt, its life history has nothing like the well-marked pattern of the Pacific salmon which, born in fresh water, normally spends most of its life in the ocean and returns to the rivers and creeks to spawn and die. Our striped bass in California spawn between March and July, with the height of the season in May in most years. There is an up-river migration each spring, carrying the fish at least as far as Knights Landing on the Sacramento, Marysville on the Feather, and Mossdale on the San Joaquin, but many go no further than the Delta region: they appear to utilize the comparatively slow-flowing tidal currents here as well as the more rapidly moving waters further upstream.

Spawning temperatures range between 60 and 75 degrees. Careful observations made near Venice Island in the San Joaquin River when the water was 67 degrees resulted in the following description (Woodhull, 1947):

"At about 3 p.m. on May 6, 1946, the striped bass first appeared at the surface slowly swimming about with parts of their backs and dorsal fins out of water. The fish seemed to be isolated females aimlessly wandering about, occasionally joined by another large fish, then sounding. At about 4 p.m. innumerable groups of from 5 to 30 large bass started to appear on the surface. These groups would mill around for a few moments, then all head up or down stream and roll over on their sides at about a 45 degree angle, at the same time throwing water in all directions with their tails. The groups of splashing fish would remain at the surface for as long as several minutes. From their actions and the position of their bodies the bass were spawning, if similarity to the actions of spawning trout can be used as a criterion."

That this actually was spawning, and not courtship, was proved by the fact that a fine-meshed net drawn through the water in the vicinity collected fertilized eggs which were only one-sixteenth inch in diameter and had therefore not yet "water-hardened"—a process which starts immediately the eggs are extruded and, in only an hour, swells them to a size of one-eighth inch.

Striped bass eggs sink, but are what is called "semibuoyant," meaning that they are so near the same specific gravity as water that the slightest disturbance will lift them off the bottom. They hatch in 48 hours at 67 degrees, in 74 hours at 60 degrees (Merriman, 1941). The young absorb the yolk-sac in a week, and form scales when about half an inch long. They grow rapidly when food is abundant and temperatures favorable, averaging four to five inches at the end of the first year, 15 inches at the third, 20 at the fifth, 32 at the tenth, 42 at the fifteenth, 47 at the twentieth. Growth takes place only from May to October; during the remaining months of the year there is no increase in size.

Males reach maturity in the second or third year and females in the fourth or fifth. Some of the females do not spawn every year thereafter but whether this is true of all, we do not know. The number of eggs is large: about 1,000,000 for a 10-pound female, 10,000,000 for a 75-pounder. Males are smaller than females of the same age.

Their diet is very broad, and includes shell-fish, crustaceans, sand-lance, herring, sardines, and the young of other fishes, including salmon and steelhead. They do not give up feeding during the spawning period, as is the case with many other species.

CATFISH FAMILY (AMEIURIDAE)

This should more properly be called the "North American catfish family," since other families of this group occur in other parts of the world. The family under consideration has nearly 50 species, ranging from Canada to Guatemala, in fresh water only. Until recently only two kinds were recognized in California, the so-called "forked-tail" and "square-tail." Now we realize that the channel and the white catfish were lumped together indiscriminately under the former term, the brown, black and yellow bullheads under the latter.

The species now in California all came originally from the middle west and the Atlantic seaboard. They are at their best in warm to moderate waters. In some of the mountain lakes where they were introduced by ill-advised persons they have become so abundant as to crowd out the trout which would normally thrive there, but remain too small to be of any value. With the exception of the channel catfish they are not highly regarded as game fish, but are excellent eating if properly prepared. They are comparatively easy to catch on a variety of baits. The 1948 estimates indicated that 19 percent of all licensed anglers fished for them and caught 5,500,000. Counties where the heaviest catches were reported, together with their percent of the total catch, were: San Joaquin 22 percent, Contra Costa 12 percent, Sacramento 10 percent, and Lake 9 percent.

All of the species present in California are spring spawners, and in most cases one or both of the parents guard the nest and the young. Their diet includes all kinds of food. To some extent they compete with other fishes, feeding on aquatic insects and their larvae; to some extent they are predatory, eating the young of other species; to some extent they are scavengers, feeding on dead fish, birds, and other carrion.

The channel catfish lives mostly in the channels of large streams. In California it is found principally in the Colorado River and tributaries. It was introduced into the Sacramento River system in 1891, but went unnoticed there for many years, possibly being confused with the white catfish. Recently several specimens have been authentically reported.

The white catfish was introduced into the San Joaquin River in 1874 and is now widely scattered throughout the State, being commonly called the "forked-tail catfish" in Clear Lake and other angling centers. That it occurs in San Diego County and probably in other parts of Southern California, has recently been verified. Like the bullheads, it has a preference for quiet or slowly moving waters.

The brown bullhead was introduced into the San Joaquin River in 1874 and is now the most widespread and abundant of the family throughout the State. The yellow bullhead, supposedly introduced in 1874, is now known only in the Colorado River drainage. The black bullhead, presumably first brought into the State in 1874 with the other species, has been reported from the Colorado River, the Kern and the

Kings. It is possible that it is more widely distributed than has been thought, and has been overlooked because of its resemblance to the brown bullhead, from which it has no definite, never-varying distinguishing features.

The channel catfish has been known to grow to 28 pounds, and the white also attains a good size, fish of eight pounds not being rare. The three bullheads are all smaller, rarely exceeding 13 inches, and therefore of less interest for sport, but the brown bullhead has in the aggregate furnished immense quantities of food.

In spite of the fact that they have been fished until recently without an angling license and with very little in the way of protective regulation, and that they have also been the subject of a commercial fishery, the catfishes have, without artificial propagation, maintained their numbers by natural reproduction throughout the years.

PERCH FAMILY (PERCIDAE)

Yellow Perch

The yellow perch, widespread in the middle west and along the Atlantic seaboard, is the only member of its family in California. First brought here in 1891, it was placed in Lake Cuyamaca, where it failed to survive, and in the Feather River. Several subsequent importations were made. By 1918 it was widely distributed in the Central Valleys, although not numerous. Very mysteriously, it appears to have vanished from these regions, none having been recorded in fish rescue since 1933. It has, however, reentered the State and is now found in small numbers in the Klamath River for some distance below Copco Dam.

It is more of a cold water fish than any of the others discussed in this paper, and in its native range frequently inhabits waters where trout thrive, with cold to only moderately warm summer temperatures. It lives in lakes, ponds, and the quieter parts of streams. It spawns in the spring at temperatures of from 45 to 55 degrees. Its eggs are emitted in ribbons, and are often found draped on twigs, stones, aquatic plants, and the like. It has been known to reach a size of four pounds, but is usually much smaller. It is caught still-fishing with worms or other bait, and is good eating.

Suggestions that efforts be made to spread this fish more widely in California are not looked on with favor by those who have studied the matter. The young perch, feeding on small acquatic organisms, would compete with the young of other game fish; the adults, eating fish, would compete with the adult game fish now present, and prey on their young. In small lakes it often becomes stunted. It is not felt that this species would contribute enough to compensate for the dangers attendant on its re-introduction to waters from which it has apparently vanished.

MANAGEMENT

The term "fisheries management" has only recently become current. The word management is used here in much the same way that it is in connection with farm or factory. The term denotes the application of those principles and practices which bring about the highest productivity at the lowest expenditure of money, time and effort.

A body of water is much like a livestock range: the number of pounds of living animals which it can support is limited. It is similar to the range in that, if too many animals are present, there will not be enough food, and none of them will thrive. It differs from the range in that, if the number of animals is reduced below what it can support, the gap will soon be made up by an increase in the number and weight of fish, whose growth and reproduction potentialities are immensely greater than those of cattle.

The fish manager suffers one important handicap as compared with his counterpart on the range: he cannot see what is going on. The cattle-grower can use his eyes to determine whether his stock is suffering because there are too many for the food supply; whether other animals of no commercial value to him, such as deer or wild horses, are eating part of the forage which ought to be going into his cows; whether wild animals are preying on his stock; whether disease is starting to spread; whether he has too many old "critters," or too many calves, for proper balance; which animals to dispose of and which to hold. To the fish manager, very little of what goes on under water is visible. He must depend on the analysis of small samples of his stock and of their food supply for the conclusions and decisions which he arrives at. Perhaps even more than a good ranch manager, a good fish manager needs specialized training.

The fields in which the fisheries manager can work are principally two. One deals with fish, the other with man. One is concerned with the effect upon the fish of his own environment, and the activities of his own and other species; the other with the effect upon fish of the activities of man. One attempts to control the fish and his surroundings, the other to regulate the extent to which man preys upon the fish.

While the term "fisheries management" itself is recent, a number of the methods have long been current. As in the case of farm and factory, some of the formerly favored ones have lost ground, and some have come to be applied in new ways. Some are successful with one kind of fish, but not with another. The striped bass, for instance, is not subject to many of the management practices applicable to the other species discussed here because it differs so much from them in one of its major population charcteristics.

Since our management methods must inevitably change as our knowledge grows, it is not desirable to discuss them in detail here. However, it is worthwhile to consider some of the problems, and some of the principles which are well enough established to be looked upon as axioms. Of these, the two most recent have developed from work done in the middlewest and south where the warm-water fishes, playing a major part in the sport fisheries as they have not done in predominantly trout-minded California, have received more study than they have here.

One is that the warm-water fishes tend to maintain at all times the full "biotic potential" of any body of water. This means that the total weight of such fishes will remain nearly constant, and close to the maximum which the given body of water is capable of supporting. If a number of the fish are removed by angling, the food which they had been consuming will be divided among those remaining, who will grow so rapidly that the total weight of fish present will soon be what it was before the removal. A corollary of this is that if very heavy fishing occurs, the natural food available for the remaining fish becomes so abundant that they cease to be interested in the less appetizing offerings of the anglers, and

fishing becomes poor. It is therefore impossible to bring about excessive depletion by hook-and-line fishing; even when a lake appears to be "fished out" there are still enough adults present to furnish an abundant crop of young for the ensuing year. And from this has developed the theory, now widely accepted, that when warm-water fishes have become established in suitable bodies of water, stocking *for maintenance* is not only not necessary, but undesirable (Hazzard, 1945). The addition of young hatchery fish puts too heavy a burden on the food supply, it no longer suffices for all, and young fish, either hatchery or naturally-born, die off until it does.

This is not a mandate against all artificial production of fish, whether in hatcheries or by "fish rescue"—which, being a human operation, can also be classed as artificial. Such fish are needed for "seed stock" in heretofore barren waters. They are needed for replacement where a catastrophe has wiped out an existing population. They may be needed for rectification of unbalanced conditions, where selective fishing has so reduced the numbers of game fish that they can no longer control the forage fish or the rough fish—conditions which sometimes become so bad that it is necessary to poison the whole population and start fresh with new fish planted in the proper numbers. They are needed for the stocking of farm ponds—the most easily managed of all waters if properly handled, and at the same time, because of their small size, the most easily unbalanced if not given proper attention (Swingle and Smith, 1947).

The second of the principles which we referred to as having been recently developed holds that in many bodies of water a large part of the warm-water fish crop remains unharvested. Many fish die of old age, without fulfilling the duty which man considers their most important one—that of contributing to his welfare. This has been shown to be the case in Norris Reservoir of the Tennessee Valley Authority (Eschmeyer, 1945). Whether it holds true for all waters throughout the country, including California, remains to be seen. But wherever this situation does exist, the first remedy is obviously to facilitate the harvesting of the crop by removal of restrictive regulations. Closed seasons, which keep the angler off the water at the time when the fish are most easily caught, have been the first targets; size limits and bag limits have been shown to be undesirable in many cases. After all, the purpose of restrictions is to spread the available fish among as many people as possible, and to provide as much fishing as possible *without injuring future angling.* Where they do not do this they should be eliminated; and some of those derived from trout management—an entirely different problem—may well be in this class.

We have discussed two of the recent developments in warm-water fisheries management. We must not overlook the basic work which forms the foundation for all management: the study of the fish and of his relation to his environment. Certain empirical findings are now accepted as correct, and will, with some modification, probably continue to be so accepted: bass, unless conditions are entirely adverse, usually predominate over trout when planted in the same water; trout require temperatures of less than 75 degrees, largemouth bass do best when temperatures reach 80 for several months of the year; best fishing results when only two or three well-chosen species are present rather than a large and heterogeneous variety, and, in small waters at least, bass and bluegills

form one of the best combinations; many of the forms of stream and lake "improvement" which seemed so promising have failed to live up to the hopes of their advocates, and it is realized that some of the best improvement work is of a preventive nature—the control of watershed erosion, and the adoption of measures which prevent power and irrigation projects from destroying existing fish populations and sometimes even turn them to fisheries advantage. As for the importation of new species, it has long been known that this can be very dangerous. While the fish introduced from outside of California have, on balance, been beneficial (Curtis, 1942), there are exceptions such as the carp, which is inimical to all game fish. Many examples exist of species which in their native region were highly beneficial becoming pests when brought into a new land where conditions differed and the natural controls were absent. It is now agreed that no introductions should be made without careful investigation, and then only under conditions where it is possible to control the exotic and to eradicate it if it gives indications of becoming an undesirable citizen.

While all of these findings may be true, they are of no value in themselves. They can not be given practical application without a thorough knowledge of the waters of the State. And it is for this reason that one of the major projects of the Bureau of Fish Conservation of the California State Division of Fish and Game is a long-range, continuing biological survey of all our waters, to determine their temperatures, their chemical and physical characteristics, and the kinds of fish and other aquatic life which they contain. Only with such knowledge as a foundation is it possible to use properly not only the management practices which are now at hand, but also those which will in the future be perfected.

The striped bass, as has been said, presents a different problem from the other fishes treated here. It forms a single, homogeneous population ranging over a wide area. Any individual may travel from Mossdale on the San Joaquin to Healdsburg on the Russian River—or for that matter, to Coos Bay, Oregon—and may in the course of its travels meet up with any one of the other members of the population. While most of the other species discussed here occur in some of the waters of the striped bass, they have not its capacity for travel, and a great many of them are confined in comparatively small bodies of water. There they can be controlled and manipulated, whereas the striped bass can not.

This means that many of the management practices which are considered applicable—although they are not necessarily always desirable—to the other species are not practical in the case of the striped bass. Artificial propagation, for instance, has been tried in various parts of the country, and has been unsuccessful except on a scale so small as to be insignificant. A 10-pound female naturally produces a million eggs in one year, and other sizes in proportion. The number of fry which it would be economically possible to produce artificially would not be a drop in the bucket compared to the billions turned out by nature.

The only management method applicable at the present stage of our knowledge to the striped bass is regulation of the catch. Existing restrictions concern only size and bag limits, but if circumstances change—if for instance fishing pressure increases enormously, or if unfavorable

developments occur in the living conditions of the fish, such as might result from some of the features of the Central Valley Project (Calhoun and Woodhull, 1948)—it is not inconceivable that further regulation of the fishery might become necessary.

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PLATE 1

Largemouth black bass *(Micropterus salmoides)*

PLATE 2

Smallmouth black bass *(Micropterus dolomieu)*

PLATE 3

Bluegill *(Lepomis macrochirus)*

PLATE 4

Green sunfish *(Lepomis cyanellus)*

PLATE 5

Sacramento perch *(Archoplites interruptus)*

PLATE 6

Striped bass *(Roccus saxatilis)*

PLATE 7

Black crappie *(Pomoxis nigro-maculatus)*

PLATE 8

Channel catfish *(Ictalurus punctatus)*

PLATE 9

Yellow bullhead *(Ameiurus natalis)*

PLATE 10

Black bullhead *(Ameiurus melas)*

A BRIEF ACCOUNT OF THE MONTEREY SPANISH MACKEREL

(SCOMBEROMORUS CONCOLOR) [1]

By John E. Fitch
Bureau of Marine Fisheries, California Division of Fish and Game
and Arthur O. Flechsig
Department of Zoology, University of California at Los Angeles

On April 28, 1949, five Monterey Spanish mackerel *(Scomberomorus concolor)* were collected by Conrad Limbaugh and the authors while on a scientific collecting trip for Dr. Boyd W. Walker, head of the ichthyology department of the University of California at Los Angeles. These fish along with numerous other species were taken in two hauls with a 100-foot seine (eight feet deep) while working an area approximately two miles south of Diggs Point, the southern point of San Felipe Bay, Lower California.

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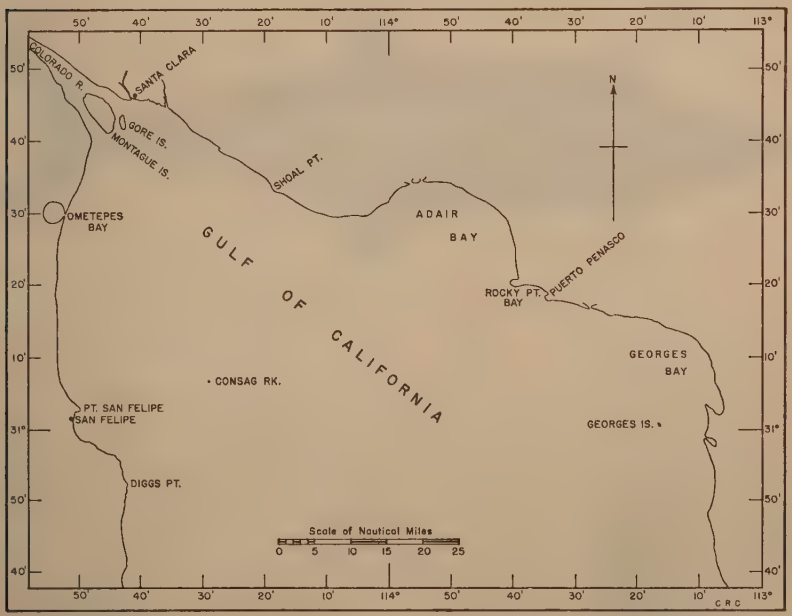

FIGURE 74—The upper Gulf of California showing important fishing villages and towns

One specimen was caught in one haul and the other four, two hauls later, nearly one-half mile farther south. In all three sets, other Monterey Spanish mackerel were in the net and either jumped over the cork line or went out around the wings before they were beached. No estimate of numbers present in the immediate vicinity could be made other than to state that they were much more numerous than the catch would indicate.

In addition, a single small (135 mm) specimen was collected by Dr. Carl L. Hubbs of Scripps Institute of Oceanography, La Jolla, in early April 1947 while aboard a shrimp trawler in the Gulf of California between San Felipe and the mouth of the Colorado River.

On February 3-4, 1949, 19 small specimens were taken by Dr. Boyd Walker, Andreas B. Rechnitzer and George Barlow, all of the University of California, also aboard shrimp trawlers, working approximately 20 miles southwest of Santa Clara (El Golfo), Sonora, Mexico. Later in February, 10 specimens of *Scomberomorus concolor* were received in a shipment of mixed species sent by a Mexican shrimp fisherman to Dr. Walker. These specimens were taken approximately 10 miles southeast of San Felipe. The species had been previously reported from the upper Gulf by Breder (1936) as taken by the "Pawnee" expedition in 1926.

Facts concerning the history of this species are almost as elusive as the fish itself has been during the past 60 or 70 years. The taking of the present specimens along with a review of much of the contemporary as well as the early literature perhaps does much toward clearing up the long standing mystery of *Scomberomorus concolor.*

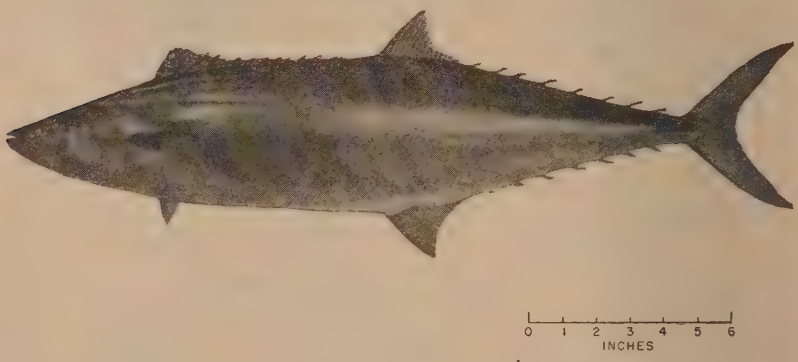

FIGURE 75—Monterey Spanish mackerel, *Scomberomorus concolor*

Phillips (1932) records two specimens landed at Monterey on March 30, 1931, and states, "From 1870 to 1880, this fish, though scarce, was taken in commercial quantities. During the eighties it disappeared entirely from the catches of Monterey fishermen and has not been seen again until this year." Walford (1937) states, "From 1870 to 1880, it was fairly common in Monterey Bay, where it was taken in commercial quantities. It was considered a great delicacy, selling for as much as one dollar a pound in the San Francisco markets. In the late eighties, however, it vanished from our coast, never to return in its former abundance. Occasional specimens appear at long intervals. One was seen in a San Pedro

fish market in 1927 and two in Monterey in 1931—proof that somewhere in the ocean there is still a stock of these fish."

Croker (1937) records a specimen from Long Beach and refers to its occurrence in the Gulf of Panama as reported by Boulenger (1899). He further relates that Boulenger did not state how many were seen and none have been reported from Panama since that date. Other California specimens were reported by Roedel (1939) and Fitch (1948). In all, six individuals were reported between the time it disappeared and the present.

In the above accounts it is indicated that this species was of considerable commercial importance in Monterey Bay in the 1870's and 1880's. This, however, does not agree too well with accounts written at the time it was supposedly abundant. In the original description by Lockington (1879b) there is no mention as to abundance and the range is given as Monterey Bay. He also states, "It is said to occasionally straggle as far north as San Francisco, or even Tomales Bay." In another paper Lockington (1879a) reports for *Chiromitra concolor,* "very few of these fishes were brought in during the autumn—by no means sufficient to supply the demand, for it is in great demand among rich gastronomists, and fetches a high price * * *. There are seldom more than two or three of this species in the markets at once."

Collins (1891) lists Spanish mackerel among the principal species of fish taken in Monterey County at that time. He also lists several other species, including yellowtail and sea bass, which are either not any longer taken or have been of no significance in the fisheries of that area for the past several decades. Collins further states that, "The Spanish mackerel *(Scomberomorus concolor)* is rare, and only a few are seen in the markets during August and September. It is highly prized and sells readily at from $2 to $3." In a footnote he explains, "The term 'Spanish mackerel,' as used in the San Francisco markets, is commonly applied to bonito, also called 'skipjack,' and 'tuna' or horse mackerel. The true Spanish mackerel *(S. concolor)* is not caught north of Monterey Bay, where a few are occasionally taken in late summer or fall."

Goode (1884) perhaps gives the most detailed information when he states, "The Pacific species may be called the Monterey mackerel. It attains a length of about 30 inches and a weight of about five or eight pounds. It has only been seen in the Monterey Bay, where from five to forty individuals are taken every fall, most of them at Soquel. They appear in September and disappear in November. Nothing further is known of their distribution or habits. They always bring a very high price in the market (30 to 50 cents per pound), the flesh being similar to that of the Spanish mackerel of the East, which species this fish closely resembles." This is one of the very few early accounts of the fishery in which any definite seasonal catch or price is mentioned.

It seems reasonable to assume from these accounts that Monterey, rather than being the center of population for this species, was the northern limit of its range, with Panama Bay the southern boundary. Those occasional individuals taken each fall in Monterey Bay were in all likelihood stragglers which had migrated farther north than the bulk of these fish. The complete disappearance of this species for nearly 40 years was possibly a result of a southward shifting of the center of population as suggested by Hubbs (1948).

Referring to the Jordan and Gilbert survey of 1880, Hubbs states, "No particularly northern type was reported for 1880, except possibly a cod, *Theragra chalcogramma* (recorded as rarely taken about San Francisco), but in contrast a considerable number of distinctly southern types were reported for that year. A Spanish mackerel, *Scomberomorus concolor*, occurred in some numbers in Monterey Bay then and during the following several years, but it is now excessively rare even in Southern California."

He further states, "The 1850 and 1860 decades appear to have been in a prolonged warm period. The fish fauna at San Diego seems to have been much more nearly tropical than it now is, and the Monterey fauna seems to have comprised many elements now characteristic of Southern California. The physical evidence for warmer waters is largely based on air temperature records."

Skogsberg (1939) gives a detailed account of the southward shifting of the center of population of the white sea bass, *Cynoscion nobilis*, from the vicinity of San Francisco and Monterey to the vicinity of Los Angeles. He assigns the time between 1889 to 1915 as the critical period of the shift and regrets that during this time no serial hydrographic observations were made in this region.

From the reports cited here it is evident that the location of the center of population for this species was not known during the time it was being taken in Monterey Bay each fall. The range can now be regarded as extending from Monterey Bay south to Panama Bay. The disappearance of these fish resulted from the gradual temperature changes of the ocean waters off the California coast. It is also probable that this species is much more common somewhere along the coasts of Lower California or the Mexican mainland than reports have indicated. It would be extremely easy for one not familiar with the species to confuse it with sierra (*Scomberomorus sierra*) which is everywhere common and even considered a pest by fishermen throughout most of the range which has been defined for *S. concolor*. The only noticeable difference between the two species is the lack of gold spots on the sides of the male of *S. concolor* and this, in most instances, would not be sufficient for the average fisherman to recognize it as rare or desirable.

Measurements are presented in Table 1 in order to supplement available data on *Scomberomorus concolor*.

Since the number of gill rakers on the first gill arch is the main characteristic which distinguishes *S. concolor* from *S. sierra*, counts were made on all 35 specimens of *S. concolor* in our possession. These counts are as follows:

	Range	*Mean*
Upper arch	5-9	7.46
Lower arch	15-20	17.6

For *S. sierra* the upper arch is given as four and the lower arch as 10 to 12.

TABLE 1

Collectors	Fitch, Flechsig and Limbaugh					Hubbs	Walker, Rechnitzer and Barlow							Mexican shrimp trawlers		Breder		Lockington type specimen
Specimen number	1	2	3	4	5	1	1	2	3	4	5	18	19	1	2	1	2	1
Standard length mm	488	580	538	545	367	135	243	229	237	212	147	190	188	134	227	491	520	
Proportions in s. l.:																		
Head	4.7	4.8	4.8	4.7	4.6	4.2	4.7	4.3	4.6	4.6	4.2	4.5	4.4	4.2	4.5	4.7	4.2	ca 4.7
Depth	5.3	5.3	5.1	5.7	5.3	4.2	4.9	4.7	5.0	4.7	4.2	5.1	4.7	4.9	4.8	5.6	5.3	ca 5
Proportions in h. l.:																		
Maxillary	1.9	1.9	1.8	1.9	1.9	1.8	1.9	1.8	1.9	1.5	1.9	1.9	1.8	1.8	2.0	1.8	1.8	
Eye	7.3	7.1	7.0	7.2	6.6	4.6	5.4	5.2	5.6	5.5	4.8	5.0	5.0	4.6	5.2	6.4	7.0	7.2
Snout	2.7	2.8	2.6	2.8	2.9	2.9	2.9	2.8	2.9	2.9	2.9	2.8	2.9	2.9	3.1	2.8	2.8	2.9
Pectorals	1.6	1.6	1.8	1.6	1.5	1.7	1.7	1.5	1.6	1.6	1.8	1.7	1.6	1.9	1.7	1.5	1.7	1.6
Ventrals	3.4	3.9	3.9	3.8	3.3	4.2	4.5	3.8	3.7	4.0	4.4	------	4.0	3.9	3.8	3.9	3.9	4.2

s. l. equals standard length.
h. l. equals head length.

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MOVEMENTS OF PACIFIC MACKEREL AS DEMONSTRATED BY TAG RECOVERIES[1]

By Phil M. Roedel
Bureau of Marine Fisheries
California Division of Fish and Game

Pacific mackerel, *Pneumatophorus diego,* range from the Gulf of Alaska south to the tip of Lower California and into the Gulf of California. They are not particularly common north of San Francisco but they are abundant off Southern California and, as far as is known, off much of Lower California. The fishery is centered in Southern California with most of the catch delivered at Los Angeles-Long Beach Harbor and at Newport Beach. The season commences in the summer, is at its peak from October to December, and falls off in the late winter. There is an erratic fishery at San Diego and a small one at Ensenada, Mexico, the southernmost port with canneries which handle mackerel. In Central California, the sardine purse seine fleets based at both Monterey and San Francisco deliver a good many loads containing some mackerel, and boats fishing in Monterey Bay for the local fresh fish markets land it in small quantities.

Given this set of circumstances—a fish with a wide distribution which is sought intensively in a relatively limited area—it becomes of prime importance to know whether individuals move freely throughout the range or whether the population consists of two or more sub-populations each with its own distribution and each more or less independent of the others. Specifically, is the Southern California fishery taking a huge toll from a local mackerel population, or is it drawing from the entire population along the coast, or at least from some portion of the population outside the bounds of the fishery? Obviously, sensible proposals for regulation can not be made without this knowledge.

Tagging fish is a simple and time-honored way of finding out whether they move from one place to another. It is a method which has been used on many kinds of fish in many countries, and many types of tags have been devised. It offers a positive approach to the study of migrations, for a tagged fish released in one area and recovered in another obviously proves migration between the areas. However, lack of recoveries in one area from fish released in another does *not* necessarily prove that there is no migration between the areas. Perhaps not enough fish were marked in the first area to give a reasonable chance of recovery in the second, particularly if migration between the two is limited. Perhaps the fish were poorly tagged and died as a result. Perhaps most of them were caught before they had a chance to migrate. Perhaps the tags fell off. However, tagging is an excellent method provided (1) the fish can be tagged without undue mortality, (2) enough can be marked in enough

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places, (3) the tag will stay in place for a long enough time, and (4) there are adequate means of recovery.

The California Division of Fish and Game has recently published a detailed report on the Pacific mackerel tagging program ("Tagging Experiments on the Pacific Mackerel (*Pneumatophorus diego*)," by Donald H. Fry, Jr. and Phil M. Roedel. Fish Bulletin 73). That report is of necessity technical, and it contains a mass of data which is of little concern to anyone but a biologist. Many of the features of the program, however, are of broader interest and the purpose of this article is to present them for the benefit of the general reader. Beside the study of migrations discussed in this article, attempts were made to obtain an estimate of the size of the exploited stock from tag returns. These efforts were not successful.

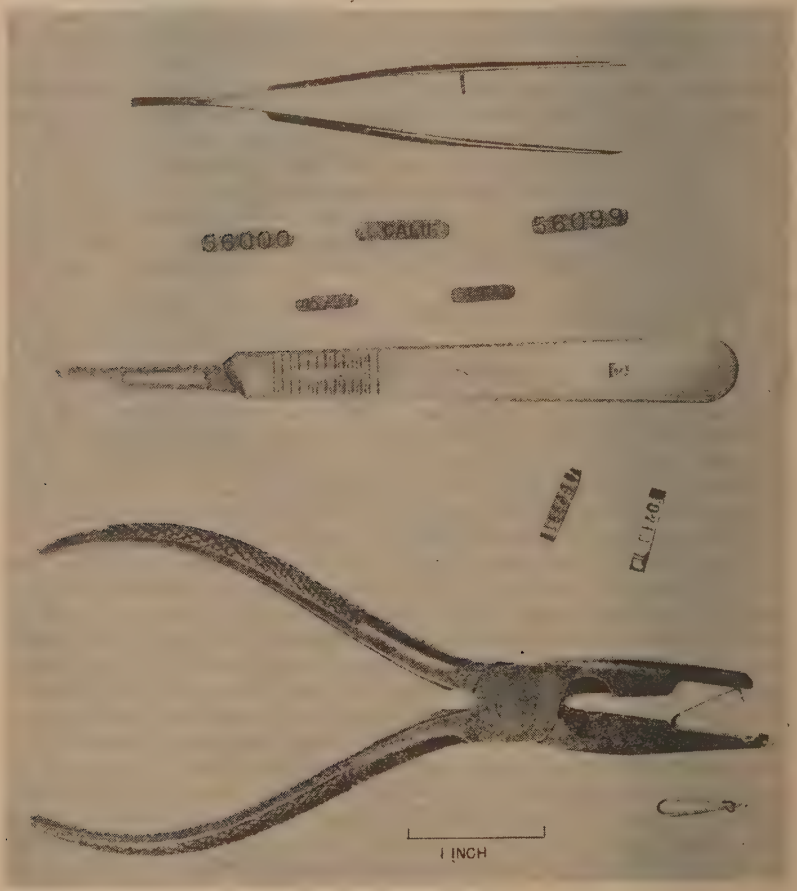

FIGURE 76—Tags and tagging tools. From top to bottom: Forceps for inserting internal tags, scalpel for making incision, opercular tags, pliers for crimping opercular tags.
Photo by Al Johns for Vernon M. Haden, San Pedro

The mackerel tagging program was inaugurated in 1935, the last fish was marked in 1943, and the last tag recovered in 1947. Over 76,000 fish were marked and released from Monterey Bay at the north to San Roque Bay in central Lower California at the south. Approximately 7,000 were tagged in Central California, 4,700 in Southern California and 22,000 in Lower California. In addition, the Biological Board of Canada tagged a few individuals off the Columbia River. It did not prove possible to tag any fish in southern Lower California and in the Gulf, or to tag an appreciable number in the Pacific Northwest. Southern California tagging was centered in the fishing season. Work in Monterey Bay was concentrated in the fall, and in Lower California chiefly in the months of October and February. The distribution of tagging effort was far from ideal, but it was the best that could be managed under the circumstances which prevailed.

At first, we used what is known as the strap opercular or gill cover tag exclusively. This tag (Figure 76) was made of nickel and was clamped in place on the gill cover with a modified pair of pliers. The theory behind the use of such a tag is that it will readily be seen by a fisherman, who will then turn it over to the proper authority, urged on by the prospect of a small reward coupled with natural curiosity as to when and where the fish was released. Many fishermen did catch tagged mackerel and did turn them in. However, it soon developed that these tags failed to stay in place. Even with their edges carefully rounded, they gradually worked a hole in the gill cover and eventually fell off. Only a few fish which had been tagged more than a year were recaptured, and most of the returns came in the first few months. This was satisfactory for checking short-term movements, but for any studies involving recaptures over a period of years the gill cover tags were useless.

Another bad feature was that commercial fishermen as a rule did not see them. In handling fish by the ton, one simply does not notice individuals. Since practically all the mackerel is caught commercially and practically all the tags were turned in by sportsmen, we obviously were not getting returns in the number we should. This was emphasized by returns of another sort. A sardine tagging program had been started shortly after the mackerel. Sardines are caught only commercially and are handled in bulk to an even greater degree than are mackerel. In tagging them, an internal or belly tag was used. This tag was made of a flat piece of metal (Figure 76) and was put in the body cavity of the fish. To do this, a small incision was made in the body wall with a scalpel and the tag inserted with a pair of forceps. These tags were recovered on electromagnets installed in each cannery's reduction plant. It is in the reduction plant that the offal from the canning lines, be it from mackerel, sardines, or tuna, along with whole sardines processed under permit, is converted into meal and oil. Mackerel gill cover tags were recovered on these magnets, further proof that the fishermen and the workers along the canning lines as well were overlooking them.

As a result, the emphasis was shifted to internal tags. They are not without their disadvantages. There is plainly little chance of a fisherman finding one in a fish. It takes time for a tag to reach the magnet, and it is impossible to tell on what day, by what boat, and exactly where the tagged fish was caught. All that can be said for a magnet return is that

FIGURE 77—Marking mackerel with internal tags aboard the research vessel *N. B. Scofield*. The fish are held in the bait well from which they are lifted to the tagging table in a dip net. In this picture, the tagger (left) is making the incision in the body wall. *Photograph by C. R. Clothier*

the fish was caught somewhere on the fishing grounds of the port in question and probably within 10 days of the date of recovery. Internal tags are thus useless for tracing short movements in limited areas but they are excellent for following migrations from one area to another over several years' time. The record internal tag came in after seven years and 11 months; the record gill cover tag after two years and four months.

Fish were tagged aboard a variety of craft ranging from skiffs to the division's 100-foot research vessel *N. B. Scofield.* A 29-foot salmon troller proved the smallest vessel on which operations were profitable. The 45-foot patrol cruisers then owned by the Bureau of Patrol were excellent, but best results were obtained on larger boats. On the *N. B. Scofield,* up to 2,000 fish a day have been tagged—about double the maximum for a small boat. Tagging was most efficient with a team of four men, one holding and measuring the fish, one applying the tag, one keeping records, and one dipping fish to the tagging table from whatever receptacle they were held in. This was normally a bait well on a larger boat and an empounding net hung over the side on a smaller one. Tagging operations are shown in Figure 77. An experienced team could mark 100 fish in 20 to 25 minutes.

Tagging mackerel is not an easy job. The mackerel is a strong fish, he is slimy, and he is armed with a needle-sharp spine at the front of his anal fin. The man holding the fish always wore cotton or wool gloves, but even so was unable to keep every individual under control. His grip had to be firm enough to keep the fish quiet, yet gentle enough to prevent injury. A certain number always contrived to squirm free of his grasp and an even greater number managed to inflict painful punctures with their spines. The tagger, when applying internal tags, used a scalpel to make the incision. Its blade was just the right width to make an opening large enough to permit entry of a tag. He had to be careful not to stab so deeply as to pierce the gut and to guard against making a wide slash through which the tag could easily fall out. Then he had to place the tag between the body wall and the gut in such a way as not to cause any internal injuries—not a simple task on a rolling boat, particularly if the mackerel wiggled at a crucial point. The process definitely killed some fish, and we soon learned that it did not pay to attempt to tag in rough weather. The fish did not survive the buffeting they received in conjunction with the less than gentle handling on the part of seasick taggers. Limited experiments indicated that even with careful tagging about a quarter of the fish would die or shed their tags within two weeks.

Tag returns gave abundant proof that mackerel move quite widely within the area covered by the program. The map (Figure 78) shows the major movements of tagged fish, together with the extent of the mackerel's range, the major fishing area, and the known spawning grounds. Only 11 individuals were marked off the Columbia River, but one of them was recaptured off Southern California. Fish tagged in Monterey Bay appeared in numbers on the Southern California fishing grounds. Southern California fish moved north to the San Francisco and Monterey areas. And fish from nothern and central Lower California were captured both in Southern and Central California. However, the farther south the fish were tagged, the fewer were the returns, and mackerel from San Roque and Thurloe Bays (the southernmost places

FIGURE 78—Major movements of tagged mackerel. Red lines denote southerly movements; black, northerly. No marked fish were released north of the Columbia River or south of central Lower California. The Gulf of California has not been explored for mackerel beyond the limit of the broken line

in which large numbers were released) appeared in our fishery in small numbers indeed. This indicates that the mackerel in that area do not make a major contribution to the fishery, and we can infer that the mackerel from still farther south contribute even less. The importance of this is that the Southern California fishery is drawing on the population from a large portion of the mackerel's range but probably not from all of it. No matter how abundant mackerel may be south of central Lower California, the odds are that they will never reach Southern California in numbers sufficient to make any appreciable difference in the catch.

The geographical restriction of the fishery imposed one limitation on the study in that there was no opportunity to recover tags south of northern Lower California. Therefore, it was not possible to demonstrate any cyclic migratory pattern which might exist. The returns did indicate a general dispersal of tagged fish. Fish released in Lower California were recaptured in California throughout the fishing season—they did not appear at any particular time within the season. There were returns throughout the season in both Central and Southern California from groups released in Southern California and from groups released in Central California.

Tagging was most consistent over the years in Southern California. Initially, the object was to show whether there was much movement within the heavily fished area itself. The work with gill cover tags demonstrated that mackerel released any one place off the Southern California coast were likely to be recaptured any place else off Southern California within the following year. Known movements of over 20 miles are shown in Figure 79. Almost all of these tagged fish were turned in by sportsmen, and consequently recovery localities are limited with one exception to the mainland coast south of Point Dume. One fish traveled at least 21 miles from Long Beach to Manhattan Beach in just 20 hours. Another purpose of tagging in Southern California was to determine the extent of migration to the north. A total of 81 tags, all of them internals, were recovered at San Francisco and Monterey. This is a surprising number in view of the limited mackerel fishery at those ports.

All of the fish marked in Central California were released in Monterey Bay. Recaptures totaled 77 in Central California and 172 south of Point Conception—a striking demonstration of the magnitude of southerly movements (Figure 80).

Recoveries from fish released in Mexican waters are shown in Figure 81. In all, 276 tagged fish were recaptured, 11 in Central California and the rest in Southern California. Most of this tagging was done in the months of October and February. Except for fish tagged at Soledad Bay, the northernmost locality, none of the fish appeared in the Southern California catch until the August following their release. That is to say, they did not enter the fishery during the season in which they were tagged, but some of them were on the grounds by the start of the next season. Several of the Soledad Bay fish, tagged in October, were recaptured off Southern California within the next few months. These fish traveled at least 100 miles, and one of them made the journey in less than a month.

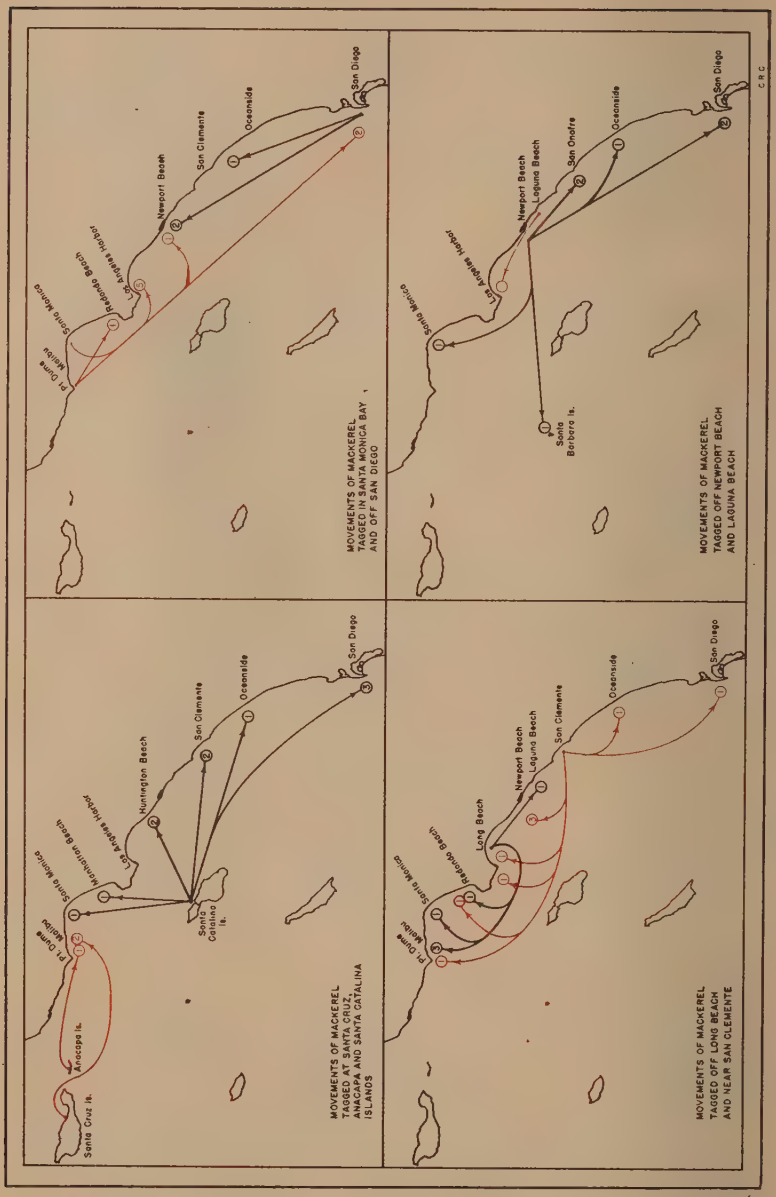

FIGURE 79.—Known movements of mackerel released and recaptured in Southern California waters. Only movements of over 20 miles are shown

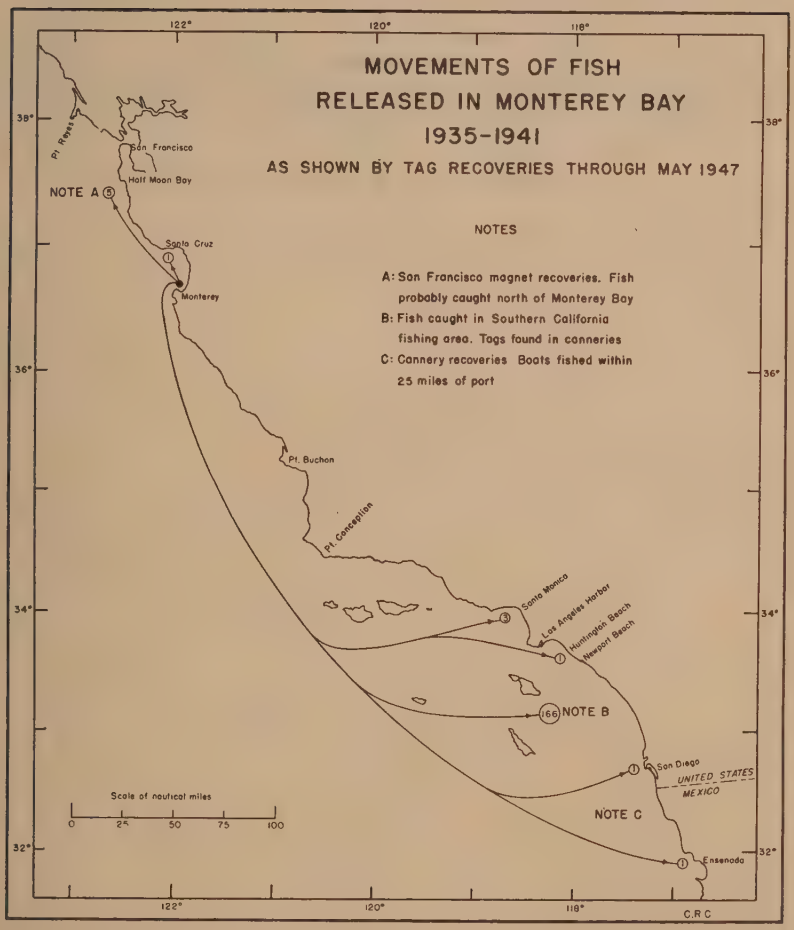
MOVEMENTS OF FISH
RELEASED IN MONTEREY BAY
1935-1941
AS SHOWN BY TAG RECOVERIES THROUGH MAY 1947
NOTES
A: San Francisco magnet recoveries. Fish probably caught north of Monterey Bay
B: Fish caught in Southern California fishing area. Tags found in canneries
C: Cannery recoveries Boats fished within 25 miles of port
122°
120°
118°
38°
36°
34°
32°
Pt Reyes
San Francisco
Half Moon Bay
NOTE A
Santa Cruz
Monterey
Pt. Buchon
Pt. Conception
Santa Monica
Los Angeles Harbor
Huntington Beach
Newport Beach
NOTE B
San Diego
UNITED STATES
MEXICO
NOTE C
Ensenada
Scale of nautical miles
0 25 50 75 100
C.R.C.

FIGURE 80

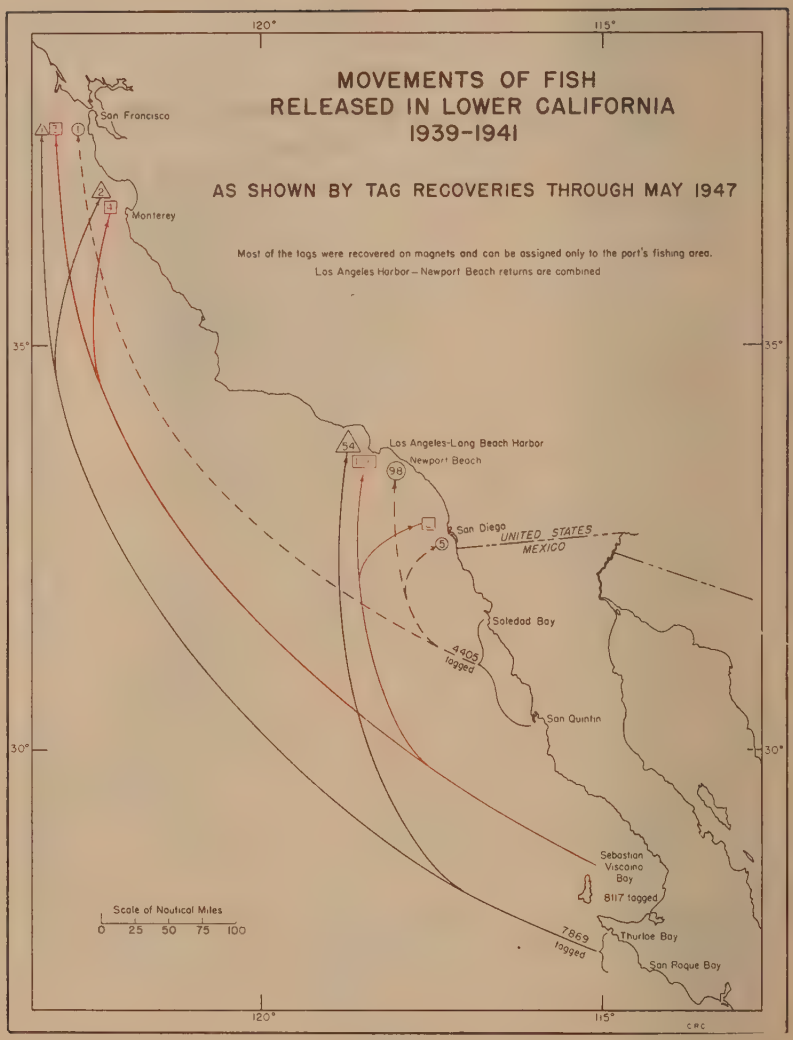
MOVEMENTS OF FISH
RELEASED IN LOWER CALIFORNIA
1939-1941
AS SHOWN BY TAG RECOVERIES THROUGH MAY 1947
Most of the tags were recovered on magnets and can be assigned only to the port's fishing area.
Los Angeles Harbor – Newport Beach returns are combined
120°
115°
35°
30°
San Francisco
Monterey
Los Angeles-Long Beach Harbor
Newport Beach
San Diego
UNITED STATES
MEXICO
Soledad Bay
4405 tagged
San Quintin
Sebastian Viscaino Bay
8117 tagged
Thurloe Bay
7869 tagged
San Roque Bay
Scale of Nautical Miles
0 25 50 75 100
CAC

FIGURE 81

There are at present no plans for resuming the tagging program. It served its fundamental purpose by showing that the Southern California industry is not dependent on a local population, that fish from as far north as Oregon and as far south as central Lower California enter the fishery in some degree, but that fish from the southernmost part of central Lower California—and, presumably, fish from still farther south—make a negligible contribution to the catch. There remain subordinate questions as to details. These are not of sufficient importance from the point of view of management to warrant the great expenditure of time and money inherent to a large scale tagging program.

THE DURATION OF HAEMOPROTEUS INFECTION IN CALIFORNIA QUAIL[1]

By Carlton M. Herman and Arthur I. Bischoff
Bureau of Game Conservation, California Division of Fish and Game

INTRODUCTION

In mosquito-borne malaria of birds, caused by *Plasmodium* sp., both the stages which infect the mosquito and the stages which continue their development in the bird occur in the circulating blood. The parasites are present in the red blood cells of an infected bird during the initial infection after which they disappear. At varying periods thereafter parasites may reappear in the red blood cells and this recurrence of the infection is referred to as a relapse. Manwell (1929) showed that in some species of avian *Plasmodium* infections relapses may occur frequently and his data indicated a possible seasonal relationship.

As early as the turn of the century Wasielewski (1901) demonstrated that after the parasites are no longer visible in red blood cells, blood is still infective when subinoculated into clean (uninfected) birds. Manwell (1934) demonstrated the persistence of infection in a large series of experimentally infected canaries over periods ranging up to three years after initial disappearance of the parasites from the red blood cells. Several cases of longer duration have been reported by other investigators and it is generally believed that a bird once infected with *Plasmodium* remains infected for the rest of its life even though it may not be possible to demonstrate parasites except during the initial infection.

The California quail, *Lophortyx californica*, is frequently infected with a malaria parasite, *Haemoproteus lophortyx O'Roke*. As far as is known the only vectors of *Haemoproteus* are blood sucking hippoboscid flies which are parasitic on the bird. O'Roke (1930) obtained infection by inoculation of sporozoites from *Lynchia hirsuta* Ferris. Kadner (1941) observed developmental stages in the fly *Stilbometopa impressa* (Bigot) but did not transmit the infection to quail. Only the stages which are infective to the vector occur in the circulating red blood cells, the other developmental stages in the bird occur in internal organs and are not observed upon blood smear examination. During the early stages of infection with *Haemoproteus* there is an initial occurrence of parasites in red blood cells as in *Plasmodium* infections.

Studies on *Haemoproteus* infections have been performed mostly with *H. columbae* in the pigeon. Sergent and Bequet (1914) believed that spontaneous cure is the rule after several years of infection and cited two specific cases, one of which recovered after two months and one after four

[1] Submitted for publication July, 1949.

8—12014

years. Coatney (1933) reported a single recovery six months following initial infection.

Wasielewski and Wulker (1918) studied *Haemoproteus* in kestrels (sparrow hawks) in Europe. They reported acute infections in young birds. Chronic infections continued for over a year and often over the entire life of the bird. "Relapses" were observed frequently, usually precluded by young stages of the parasites appearing in the red blood cells. They observed an increase in intensity of parasitemia in the spring, a decrease in the fall and winter. No mention was made of the duration of relapses nor the intervals between relapses and there is no indication that any of their birds were kept free from possible reinfections.

O'Roke (1932) classified infections with *H. lophortyx* in the California quail as mild, chronic; mild, acute; moderate, chronic; and heavy (or fatally) acute. In his discussion of the mild, chronic type of infection he stated that this type is extremely persistent, extending throughout the year. He examined blood smears from a total of 312 quail from various places in California, including Santa Catalina Island, and found infection to be present in most areas. Of the 312 birds he studied, 45 percent were parasitized. Parasites were present at all seasons of the year when examinations were made.

Herman and Glading (1942) reported on the examination of blood smears obtained from quail during the months of August through February from September 1937 to September 1940 at the San Joaquin Experimental Range, California. A total of 503 birds were studied. Total infection in all birds examined was 84.3 percent; the highest infection rate in any one age group was 93.5 percent in birds four months to one year old. Parasites were present during all months when samples were taken.

The present study was instigated to find a basis for evaluation of survey data obtained from examination of blood smears currently on hand from a large series of wild trapped California quail. The chief problems were to determine whether these parasites persist in the circulating red blood cells after a quail recovers from the initial infection, whether relapses occur and how long a bird may remain infected.

MATERIALS AND METHODS

Most of the birds used in this study were adult California valley quail, *Lophortyx californica vallicola*. They were obtained either from Dune Lakes, on the coast of San Luis Obispo County, or from Bitterwater in San Benito County, California. All were naturally infected with *Haemoproteus lophortyx* when trapped and when assigned to this study. The birds were secured through the cooperation of personnel of the Federal Aid in Wildlife Restoration Project California 6R, particularly David Selleck.

Any flies that may have been on the birds were removed at the time they arrived at the laboratory. The quail were then placed in screened fly-tight cages for the duration of the study. Thin blood films were procured three times each week; all intervals between smears were either two or three days.

The blood films were stained with Giemsa stain and examined with a compound microscope using the oil immersion objective. Periods of

examination varied depending on the number of parasites present. Before any individual smear was considered negative it was examined for at least one-half hour. In 10 of the birds, all parasites seen in the first 1,000 red blood cells examined in each smear were drawn diagrammatically to scale with the aid of a camera lucida. Further examination of the slides was included if this was necessary to determine the intensity of the parasitemia on the basis of number of parasites per 10,000 red blood cells. In six other birds included in the study, examination was made only to determine the intensity of the parasitemia. A single induced infection is included in this report.

RESULTS

Duration of Infection

Blood smears were started on 10 naturally infected adult quail on March 23, 1943. These birds were obtained from the Dune Lakes area. Quail 409 was killed on May 3, 1943. The other nine quail died consecutively on July 30, November 30, December 8 and December 11, 1943; January 26, January 28, June 12 and June 29, 1944, and May 3, 1945. All showed parasites more or less continuously throughout the study.

Blood smears were started on six naturally infected adult quail on February 28, 1944. These birds were obtained from the Bitterwater area. They died consecutively on April 12 and November 20, 1944, March 10, 1945, two on December 15, 1946, and the last on November 6, 1948. All showed parasites more or less continuously throughout the study.

On August 23, 1944, a specimen of hippoboscid fly, *Stilbometopa impressa,* was collected from a wild-trapped quail demonstrating a severe parasitemia with *Haemoproteus lophortyx.* Examination of the blood film prepared from this quail revealed over 5,000 parasites per 10,000 red blood cells. The fly was dissected and found to contain sporozoites, the infective stage of the parasite, in the salivary glands and body cavity. Material including the salivary glands was macerated in a physiological saline solution and inoculated into the breast muscle of an immature female quail. The recipient was a bird trapped in San Francisco and showed no parasites in its blood. This bird was approximately 14 months old. In examination of a large series of trapped quail from various locations within the city of San Francisco none have ever been found to be infected with *Haemoproteus.* Parasites were first observed in the recipient 21 days after the inoculation and the bird succumbed to the infection 10 days later.

In view of the fact that all of the naturally infected birds in this study were adults, it is not known how long they might have been infected before they were assigned to this study. Duration of infection varied depending on how long the birds were kept under observation. It is assumed from this data that quail infected with *Haemoproteus lophortyx* may remain infected with the parasites for their entire life. The longest duration observed was from February 28, 1944, to November 6, 1948, or a period of over four years, eight months.

Intensity of Infection

The extent of the parasitemia, or the number of parasites occurring per unit of 10,000 red blood cells was used as a basis for evaluating the intensity of infection.

In the experimentally infected bird, infected by inoculation of material from the hippoboscid fly, the parasites increased steadily in numbers from seven per 10,000 red blood cells on the first day they were observed to 2,900 on the eighth day following recognized parasitemia, then dropped to 1,879 in the blood smear made on the 10th day about two hours before it died. The quail was droopy for three days prior to death and refused food and water during this period. Necropsy revealed an enlarged dark spleen characteristic of the malarias. The bird was not emaciated.

All the naturally infected quail presented a parasitemia at the time that they were assigned to this study. Table 1 shows the variation in intensity in these birds throughout observation. Herman and Glading (1942) established an arbitrary classification for intensity of parasitemia and this has been followed in the tabulations in the present paper.

TABLE 1

Variation in Intensity of Parasitemia With Haemoproteus in Naturally Infected Quail

Bird number	Number of slides	NOF *	A *	B *	C *	D *	E *
409	18					5	13
944	19			9	10		
427	56			12	24	20	
396	105			6	30	69	
448	108		2	55	43	8	
456	109			22	66	21	
035	113	12	64	29	17	3	
454	127	5	121	1			
455	125		3	71	29	22	
456 II	158	14	44	63	21	10	5
442	185		29	111	30	15	
439	190		1	58	66	65	
452	303	17	99	108	53	26	
069	437	37	249	55	38	36	22
176	437	66	188	137	40	6	
186	731	70	259	307	80	12	3

* NOF, no organisms found; A, less than 10 parasites per 10,000 red blood cells; B, 11-50; C, 51-100; D, 101-500; E, 501-1000.

Quail 409 demonstrated the D infection in the first five smears with the parasites steadily increasing until it was sacrificed to procure tissues for pathological study. In all the other birds the intensity of parasitemia fluctuated up or down, in many cases skipping two degrees of the classification from one smear to the next within the period of two or three days. Nine of the 16 birds demonstrated parasites in all smears made during the study.

The negative findings are of particular significance. In all cases where no organisms were found in a blood smear, subsequent smears at later dates demonstrated parasites and all birds had parasites in the red blood cells in the last blood smear taken. Quail 186 was negative throughout a period of over four months during the second year of observations (July through October) and subsequently reached a parasitemia of E intensity. One must therefore proceed with caution when interpreting recovery in a bird once infected.

In all cases, except Quail 409, the highest peaks of parasitemia were reached during the months of February, March or April.

Nature of Infection

In *Plasmodium* infections recurrence of parasitemia in birds which have demonstrated no parasites in their blood cells for a varying period is interpreted as a relapse. Where the parasites can be observed almost continuously in infections of *Haemoproteus*, such as *H. lophortyx*, interpretation of relapse must be based on other factors. As pointed out in the introduction of this paper several workers, studying *Haemoproteus* infections in other hosts, have observed fluctuations in intensity of parasitemia and have reported the appearance of young stages of the parasites at the beginning of a recurrence of parasitemia. Coatney (1933), reviewing these reports and interpreting the results of his own investigations on the *Haemoproteus* of domestic pigeons, suggested that the appearance of young stages of the parasites in the circulating red blood cells be used as a criterion of occurrence of relapse.

In Quail 409, where the parasite number increased steadily for a period of over five weeks, only fully matured parasites were observed in the cells of the circulating blood. In the experimentally infected quail young stages of the parasites predominated in all six blood smears demonstrating parasites, including the last smear prior to death which showed a drop in intensity.

In order to interpret the significance of increase in young stages of the parasite as a possible indicator of relapse, camera lucida sketches of the parasites were made throughout the study in 10 quail. Figure 82 presents a typical picture of what occurred. The bars represent the ratio of number of young per 100 mature parasites, the line graph indicates the total number of parasites per 10,000 red blood cells. As reported by earlier investigators who studied the *Haemoproteus* infections in other hosts, it will be noted that the highest peaks of total parasitemia were preceded by a very marked increase in the immature-adult ratio. As a general rule in all the infections under observation slight increases in parasite number were not accompanied by an increase in the proportion of young stages while a marked increase in parasite number was usually preceded by a sharp increase in the immature-adult ratio. Parasitemia intensity often doubled or tripled without the appearance of immature forms of the parasites in the circulating blood suggesting that perhaps a complete interpretation of the mechanism of relapse and the continual occurrence of only adult stages of the parasites in the circulating blood must await clarification of the course of the asexual cycle as it occurs in the internal tissues of the host.

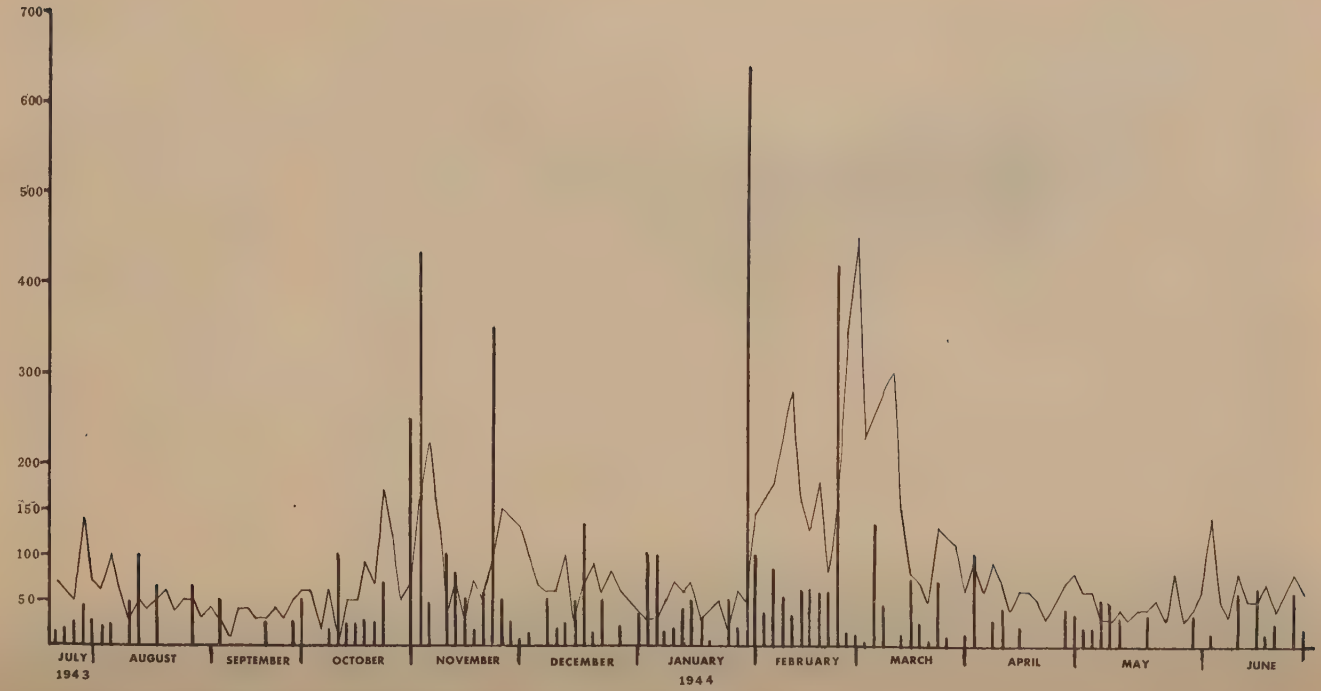

FIGURE 82. Comparison of parasitemia intensity per 10,000 red blood cells and ratio of number of immature stages per 100 mature stages of the parasite as an indicator of relapse in quail 439. Vertical bars indicate the ratio, line graph shows the parasitemia

SUMMARY

Blood smears were procured three times per week from 16 adult California quail with natural infections of *Haemoproteus lophortyx*. All the birds were kept in fly-tight cages. The smears from all the quail showed parasites more or less continuously throughout the study for periods ranging from several weeks to over four years and eight months. It is concluded that quail once infected with *H. lophortyx* remain infected throughout their life.

In all but one bird the intensity of parasitemia fluctuated during the observations. The occurrence of negative smears for extended periods with subsequent reappearance of parasites makes questionable the interpretation of recovery on the basis of negative findings. Peak of infections was during the months of February, March or April.

As a general rule marked increase in parasite number was preceded by increase in immature-adult ratio not present with slight increases in parasitemia.

A quail was infected by intramuscular inoculation of sporozoites from *Stilbometopa impressa*. Incubation period was 21 days. Parasitemia increased until just before death 10 days later with a predominance of young stages throughout.

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A PROGRESS REPORT ON PHEASANT HUNTING SEASON STUDIES FOR THE YEARS 1946, 1947 AND 1948[1]

By
Carol M. Ferrel, Harold Harper and Jack Hiehle
Bureau of Game Conservation
California Division of Fish and Game

California hunters had their first state-wide pheasant hunting season in 1933. Since then the seasons have been a maximum of 10 days duration and have been characterized by heavy hunting pressure on areas where property owners allowed unlimited public hunting. In order to study the effects of this heavy hunting pressure on the pheasant population, two pheasant study areas were established in typical Sacramento Valley pheasant habitat.

The primary objectives of this study were to obtain: (1) information on hunting pressure and hunter success, (2) old-young ratio of the kill, (3) data necessary for calculation of total populations, (4) information on the kill of game farm birds, and (5) a comparison of the kill on an area stocked with game farm birds and an unstocked area.

DESCRIPTION OF STUDY AREAS

The Sartain Ranch, 12 miles west of Gridley in Colusa County, is a corporation ranch under the direction of Mr. Terrill Sartain. The study area included 6,920 acres, the bulk of which was open to unlimited public shooting. In 1947, 260 acres and in 1948, 1,280 acres surrounding ranch headquarters were reserved as a safety zone and for restricted hunting under control of the landowner.

The McManus area is located north of the Sartain Ranch in Glenn County. The ownership of the 7,800 acres under study is divided among six individuals. In 1948, 960 acres lying along the west border of the area was under lease to a commercial hunting club. Hunting on this club was moderate and comparable in intensity to the land closed to the general public on the Sartain Ranch.

The land between the two study areas is dry unirrigated grain land, at least three and one-half miles wide with sparse cover; it acts as a barrier to movements of birds between the areas.

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Federal Aid in Wildlife Restoration Act, California Project 22-R. The authors wish to acknowledge important contributions to this study made by Howard Twining, former leader of Project 22-R, and Wallace Macgregor, former Project 22-R assistant. Also, thanks are expressed to the numerous bureau personnel, mostly from the State Game Farms, who served as hunter interview officers.

Crop acreage for the study areas for 1947 and 1948 are summarized in Table 1. There has been no change in the general crop pattern since the study was inaugurated. However, the acreage devoted to the various crops has fluctuated from year to year. For example, a reduction of over 600 acres in the amount of land in rice occurred on both areas in 1948.

TABLE 1

Crop Acreages for the Two Study Areas

		Rice stubble	Fallow rice	Barley stubble	Plowed leveled	Pasture	Total
Sartain	1947	3,160	0	760	2,960	40	6,920
	1948	2,535	0	535	3,620	230	6,920
McManus	1947	3,360	80	2,960	600	800	7,800
	1948	2,722	603	3,194	772	509	7,800

The acreage of plowed and leveled land on the Sartain Ranch represents land which was in barley during the spring and summer and corresponds to the barley stubble of the McManus area. It has been the practice on the Sartain Ranch to plow the harvested barley fields prior to the hunting season when data for Table 1 were collected.

The Sartain Ranch has been stocked with game farm birds, with cocks in 1946 and with both cocks and hens in 1947 and 1948. No stocking of game farm birds has been done on the McManus area.

HUNTER CHECKING PROCEDURE

The data presented in this paper are based primarily on information obtained during the hunting seasons of 1946, 1947 and 1948. The hunting season in 1946 extended from December 6 to 15; in 1947 from November 21 to 30; and in 1948 from November 19 to 28, all dates inclusive. Daily shooting time was 10 a.m. in 1946 and 8 a.m. in 1947, and 1948. All shooting was stopped at one-half hour after sunset daily in all three seasons. A daily bag limit of two cocks and a seasonal limit of 10 was in force the three seasons.

Both study areas are traversed by main roads from which numerous ranch roadways lead throughout the fields making the pheasant hunting grounds readily accessible. Permission from the owners has been required for hunting on the property; however, permission has been granted for the asking. During the 1948 season issuance of hunter permits on the Sartain Ranch was managed by Division of Fish and Game personnel. Mr. Sartain asked that the division do this in order to ease the burden of being host to the thousands of hunters shooting on his ranch. The owners of the McManus area issued their own permits.

During the 1946 hunting season an attempt was made to collect data from the hunters by interviewing them in the fields or by checking them at their vehicles when they returned from hunting. This proved unsatisfactory because it was felt that more data could be derived by more efficient use of the limited personnel available. In 1947, checking stations were set up on all roads leading out of the study areas. All vehicles were requested to stop and the hunters were interviewed as they left the areas. As a result of this technique more satisfactory data was obtained for the

1947 and 1948 seasons. In general the hunters have proved to be amiable to such a system and willingly cooperated with the interviewing officers.

The type of data procured included information regarding the area checked; number of hunters per vehicle; county of hunter residence; number of birds bagged; number of hours hunted for day interviewed; total number of days hunted; and, for a sample of the kill, the depth of the bursa of Fabricius as an age indicator. When banded birds were checked supplemental data yielded information regarding game farm stock in the kill.

During the hunting season the Sartain Ranch was posted with signs advising the hunters that the ranch was open to hunting with permission and that the ranch was an experimental pheasant study area. When the permits were issued each hunter was informed that he was expected to stop for interview on the way out of the ranch. No special posting of the McManus area was done except the placing of signs designating checking stations.

CHECKOUT RESULTS

Totals for the 1948 hunting season, together with comparative figures for the 1947 season, are presented in Table 2.

TABLE 2

Composite Summary of Hunter Check

Area	Cars checked	Hunters checked	Total kill	Hunters per car	Birds per hunter
Sartain 1947	1,029	2,592	1,023	2.52	0.39
1948	2,225	5,836	3,230	2.62	0.55
McManus 1947	906	2,375	958	2.62	0.40
1948	1,686	4,223	2,656	2.50	0.63

There were 3,244 more hunters on the Sartain Ranch in 1948 than in 1947, an increase of 125.1 percent. Increase in total kill was 2,207 cocks or 215.7 percent. On the McManus area there was an increase of 1,848 hunters, or 77.8 percent, while total kill increased by 1,698 birds, or 177.2 percent.

Airplane Census of Hunters' Cars

An airplane census of hunters' cars was made in 1947 and 1948 each morning for the first three days of the season. Censusing was started one-half hour after shooting time (8 a.m. Pacific Standard Time) and continued until 10 a.m. each day. The area censused, which was covered by flying in strips was bounded on the south by the Gridley-Colusa road, on the west by the Sacramento River, on the east by Highway 99E, and on the north by a line from Chico west to the Sacramento River. These boundaries enclose an area of approximately 269 square miles. All cars, whether on or off the road, were counted. However, allowances were made for farm trucks and cars considered to belong to local residents.

TABLE 3

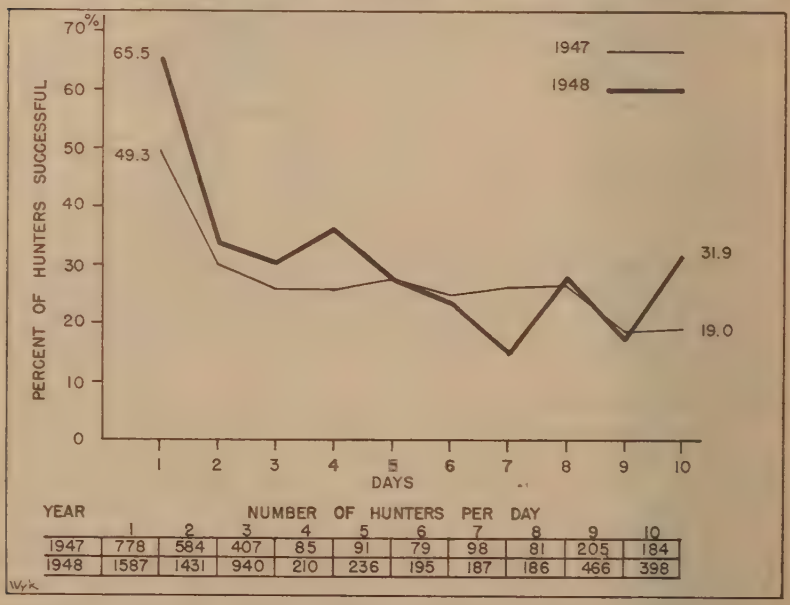
Airplane Census Results

		Total cars	*Average number hunters per car	Total hunters	Cars per square mile	Hunters per square mile
1st day	1947	1,713	2.6	4,437	6.4	16.5
	1948	2,198	2.6	5,649	8.2	21.0
2d day	1947	1,349	2.6	3,507	5.0	13.3
	1948	2,056	2.7	5,551	7.6	20.6
3d day	1947	1,149	2.5	2,895	4.3	10.8
	1948	1,507	2.7	4,039	5.6	15.0

* Computed from averaging number of hunters per car for both the Sartain and McManus areas and applying them to the large area. (Sartain and McManus areas excluded from total.)

A summary of the results is presented in Table 3. It should be pointed out that the totals presented do not represent the total cars on the hunting grounds for the entire day, but only for the time in the morning during the census period.

By counting the cars by airplane on both the Sartain and McManus areas and comparing those totals with daily totals as counted at the



YEAR	NUMBER OF HUNTERS PER DAY									
	1	2	3	4	5	6	7	8	9	10
1947	778	584	407	85	91	79	98	81	205	184
1948	1587	1431	940	210	236	195	187	186	466	398

FIGURE 83—Percent of successful hunters and number of hunters per day, Sartain Ranch

checking stations it was found that the morning air census gave an average for the three mornings of 72.8 percent of the actual daily total on the Sartain Ranch and 47.7 percent on the McManus area.

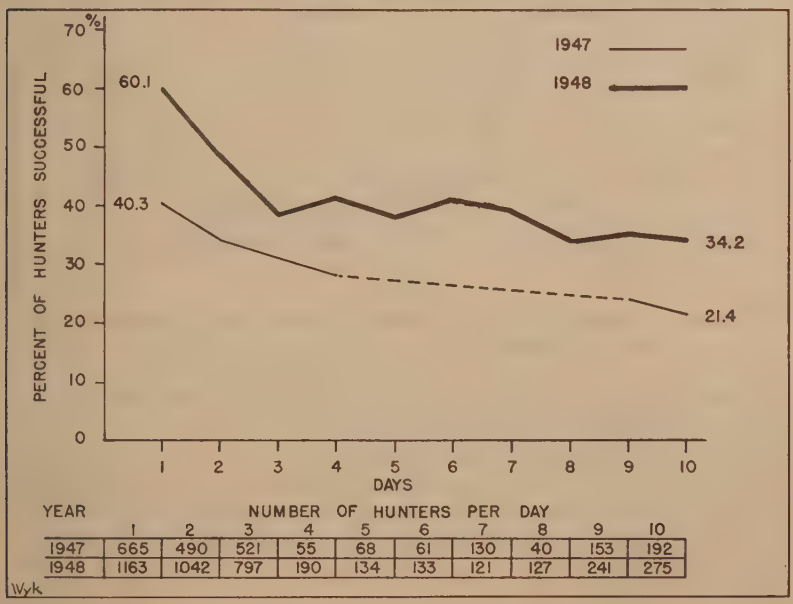
An examination of the number of hunters' cars censused the first three days of the 1948 season by airplane revealed an increase of 36.8 percent over the 1947 season's results. This figure can be used as an indicator of the general increase in hunting pressure in the northern Sacramento Valley during the 1948 season. However, on the Sartain area the number of vehicles increased 115.0 percent and on the McManus area 82.4 percent for a similar period.

The two study areas showed an increase in hunting pressure out of proportion to the other parts of the pheasant habitat because of the wide publicity they received as areas where permit hunting was allowed.

Hunter Success

Number of hunters per day and percent of successful hunters by day for the Sartain Ranch for the 1947 and 1948 hunting seasons is shown in Figure 83 and similar data for the McManus area is presented in Figure 84.

The Sartain Ranch had a higher percent of successful hunters the first day of the 1948 season than the McManus area. However, after the



YEAR	NUMBER OF HUNTERS PER DAY									
	1	2	3	4	5	6	7	8	9	10
1947	665	490	521	55	68	61	130	40	153	192
1948	1163	1042	797	190	134	133	121	127	241	275

FIGURE 84—Percent of successful hunters and number of hunters per day, McManus area

first day the success on the McManus area remained uniformly higher than on the Sartain area. Also the McManus area showed a less abrupt drop in hunter success. It is felt that this condition is mainly attributable to the fact that fewer hunters used the McManus area.

In Figure 84 complete data was not available for 1947 for the fifth to the eighth days. The marked increase in hunter success the last day of the season on the Sartain Ranch was undoubtedly due to the opening of the restricted area closed to the general public earlier in the season.

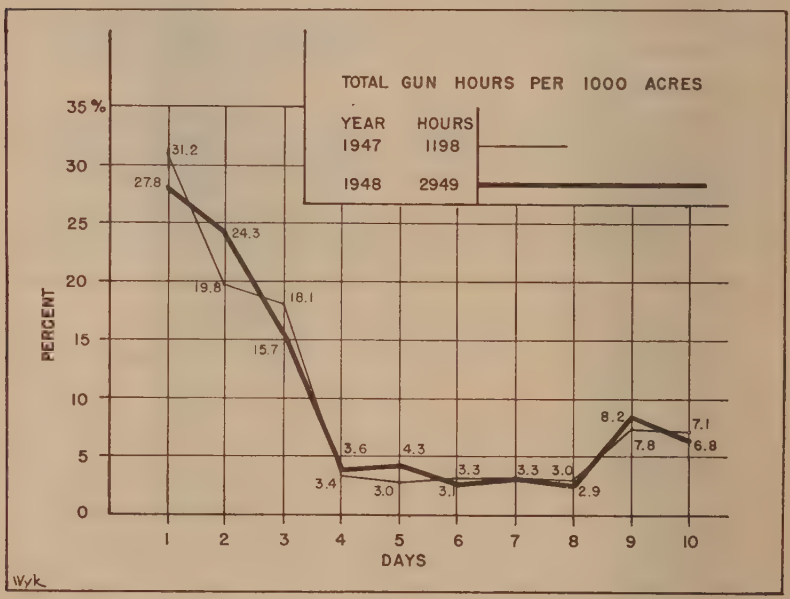


FIGURE 85—Daily percent of gun hours, Sartain Ranch

The closed portion was heavily populated by birds which had flown in from the surrounding heavily hunted area.

Number of Days Hunted per Hunter per Season

Apparently but few hunters spent more than three days in the field during the 10-day season. Those who did were mainly local residents. Of hunters interviewed the last day during the 1948 season only 19

percent on the Sartain Ranch and 15 percent on the McManus area had hunted more than three days. On the Sartain Ranch 2 percent and on the McManus area slightly over 1 percent of the hunters had spent all 10 days in the field.

Gun Hours

The daily percent of total gun hours and the total gun hours for 1947 and 1948 seasons on the Sartain Ranch is presented in Figure 85. The same data for 1948 is shown in Figure 86 for the McManus area. Comparable data for 1947 on the McManus area is not available.

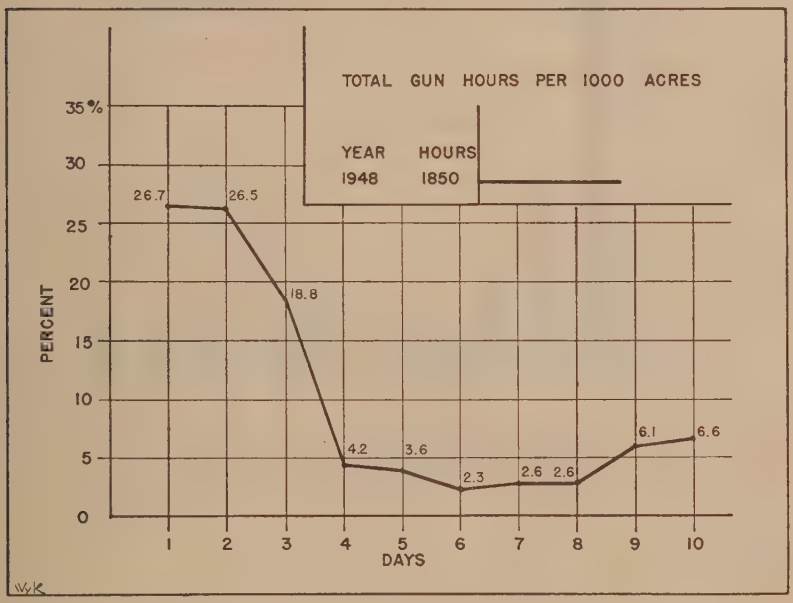


FIGURE 86—Daily percent of gun hours, McManus area

On the Sartain Ranch 69.1 percent of the gun hours were on the first three days of the season in 1947 and 67.8 percent on the first three days in 1948. On the McManus area 72.0 percent was expended the first three days in 1948. Comparable data for the McManus area is not available for 1947.

Birds Killed per 1,000 Acres

Figures 87 and 88 show the number of birds killed per 1,000 acres for the Sartain and McManus areas for the 1947 and 1948 seasons. Kill per 1,000 acres in 1948 exceeded that for the 1947 season on all days of

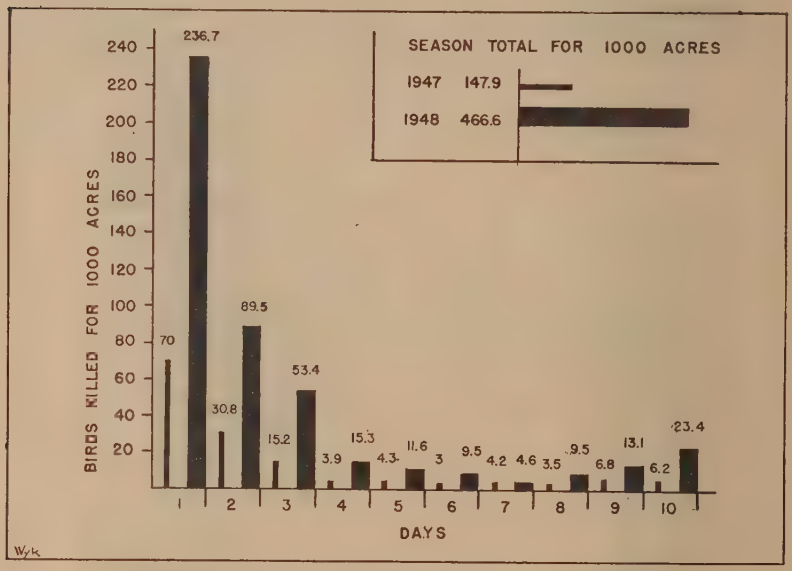


FIGURE 87—Daily kill per thousand acres, Sartain Ranch

the hunting season. For the Sartain area 466.6 birds per 1000 acres were taken in 1948 while 147.9 per 1000 acres were taken in 1947 or over three times as many. On the McManus area the number of birds killed per 1,000 acres was 122.8 in 1947 and 340.5 in 1948, slightly less than three times as many.

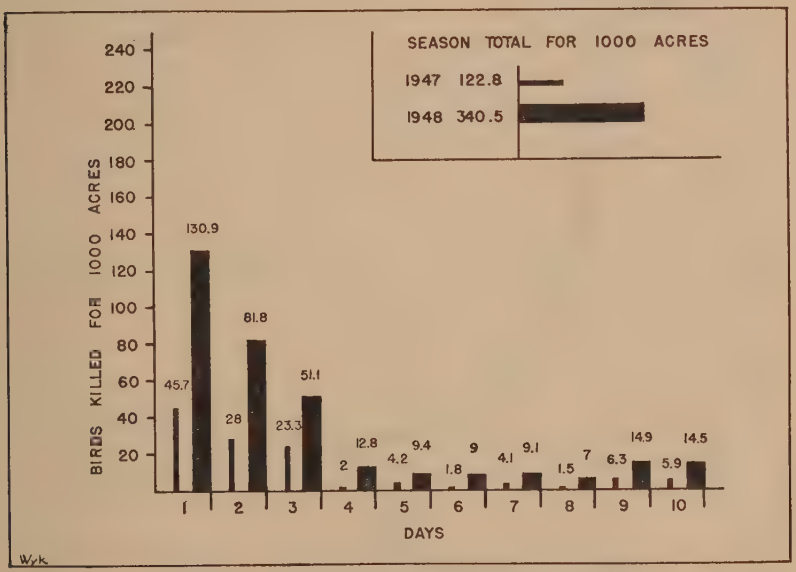


FIGURE 88—Daily kill per thousand acres, McManus area

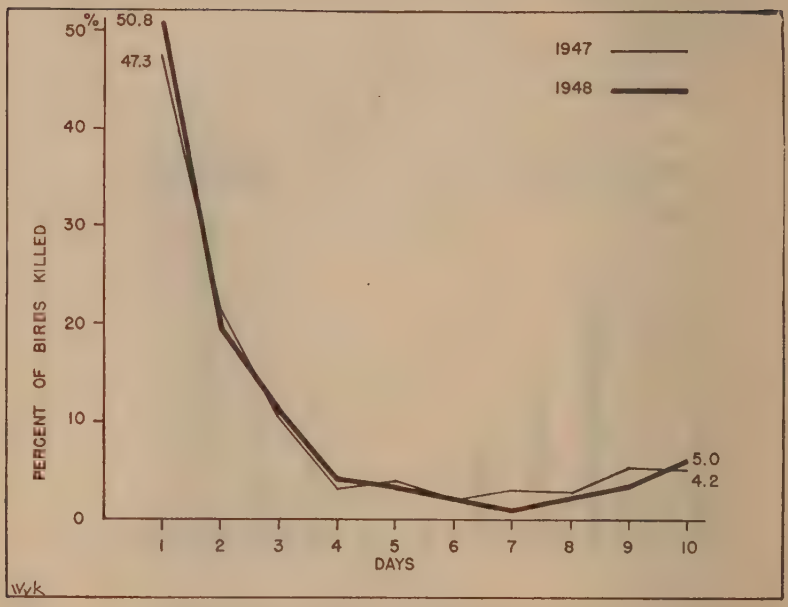


FIGURE 89—Daily percent of kill, Sartain Ranch

Daily Percentage of the Kill

Daily percentage of the total kill on the Sartain Ranch for the 1947 and 1948 seasons is shown in Figure 89 and the same data for the McManus area is presented in Figure 90.

On the Sartain Ranch 50.8 percent of the kill occurred on the first day of the season and 81.4 percent on the first three days. During the 1947 season 78.6 percent was taken on the first three days.

On the McManus area 38.4 percent of the kill occurred on the first day and 77.4 percent on the first three days of the 1948 season. In 1947 79 percent was taken during the first three days.

The heavier hunting pressure on the Sartain Ranch (see Table 5) tended to make the opening day kill as shown in Figure 89 greater than for the McManus area (Figure 90) and the decline was more rapid. However, on the fourth and subsequent days of the season the daily percentages of the kill for the two areas was similar.

Origin of Hunting Pressure

Percent of hunters by region of home residence hunting on the Sartain and McManus areas for the 1947 and 1948 seasons is presented

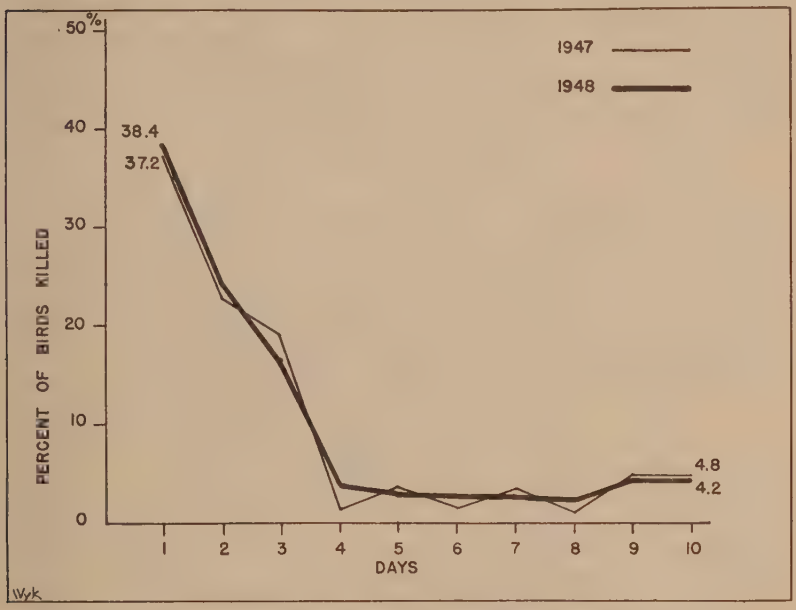


FIGURE 90—Daily percent of kill, McManus area

in Table 4. Complete week-day data for the 1947 season on the McManus area is not available.

Although the borders of the study areas are only 3.5 miles apart, the Sartain area was used as a hunting ground by a higher percentage of nonlocal hunters than the McManus area. More hunters from the San Francisco Bay area hunted the Sartain Ranch. In fact, on the Sartain Ranch during the 1948 season, the percentage of San Francisco Bay region hunters exceeded that for local hunters on all days. This was a change from the 1947 season when the percentage of local hunters was greater than nonlocal during the weekdays and final weekend of the season.

TABLE 4

Percent of Hunters by Region of Residence, 1947 and 1948 Seasons

	McManus area						Sartain area					
	Opening 3 days		Weekdays		Final weekend		Opening 3 days		Weekdays		Final weekend	
	1947	1948	1947	1948	1947	1948	1947	1948	1947	1948	1947	1948
1 Local	50.5	49.5	----------	58.0	66.8	56.5	29.7	29.2	58.2	35.5	39.3	26.8
2 San Francisco bay region	27.9	29.0	----------	19.6	17.0	24.2	43.3	47.0	19.6	37.4	37.7	59.2
3 Southern California	5.3	3.8	----------	7.5	2.3	1.5	6.2	6.7	6.9	9.8	0.0	0.6
4 San Joaquin valley	3.4	5.1	----------	4.0	1.2	3.9	6.1	3.9	2.6	3.2	3.5	1.5
5 Sacramento	5.0	3.5	----------	2.8	4.6	3.5	6.0	6.7	6.7	7.1	14.4	4.7
6 Other	7.9	9.1	----------	8.1	8.1	10.4	8.7	6.5	6.0	7.0	5.1	7.2

1. Local—Plumas, Butte, Colusa, Glenn, Sutter, Yuba, Nevada Counties.
2. San Francisco Bay Region—Marin, Solano, Contra Costa, Alameda, San Francisco, San Mateo, Santa Clara, Sonoma, Napa Counties.
3. Southern California—Santa Barbara, Orange, Los Angeles, Riverside, San Bernardino, San Diego, Ventura, Imperial Counties.
4. San Joaquin—San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Kern, Tulare, Mariposa, Tuolumne Counties.
5. Sacramento—Placer, El Dorado, Amador, Sacramento Counties.
6. Other—All other counties.

Hunters per 1,000 Acres

The number of hunters per 1,000 acres for both areas for 1947 and 1948 is presented in Table 5. Hunting pressure on the two study areas was unevenly distributed. Extremely heavy and evenly distributed hunting occurred on the land in rice stubble but away from the rice, hunting is restricted to areas of cover such as marshy spots and weed patches. The large acreage of plowed and leveled land on the Sartain Ranch (see Table 1) was thinly populated with pheasants and lightly hunted.

Old-young Ratio of Kill

The method employed in aging the birds was by probing the bursa of Fabricius to determine its depth. This method has been described by Kirkpatrick (1944). The results obtained are considered accurate since only experienced men were employed to take the measurements, and a sample of the kill was taken throughout the season.

Other methods of aging, such as examination of spur length or testing the hardness of the lower mandible, were not used during the 1948 season since results obtained by project personnel using these methods in past seasons had given extremely variable results.

Table 6 presents the results of bursa measurements for the 1947 and 1948 seasons. Figure 91 gives the frequency distribution of bursa depths from birds killed at the Sartain Ranch and the McManus area for the 1948 season. The results for 1948 and for other seasons have led us to classify the six to eight mm. groups as intermediates. These birds are either adult pheasants which have retained a deep bursa or young birds whose bursae have partially closed.

The kill on the Sartain Ranch included 11.7 percent adult birds in 1947 and 4.1 percent in 1948. The McManus area had 15.9 percent adults in the 1947 kill and 13.4 percent in 1948. As the 1948 breeding season had been unusually successful the reduction in the number of adult birds in the 1948 kill was expected. Leopold (1949) in studies made on the Conaway Ranch [1] where moderate controlled hunting was practiced found 26.4 percent adults in the 1947 kill and 35.7 percent in 1948. Probably the low number of adults in the kill of the two study areas is due in part to the fact that the intense hunting pressure which occurred on these areas left but a small carry over of cocks to the following season. It appears therefore that the study area is mainly dependent on birds of the year for filling the hunters' bag.

[1] The Conaway Ranch comprises 18,800 acres in good pheasant habitat located in Yolo County in the southern part of the Sacramento Valley approximately five miles southeast of Woodland. (Controlled hunting is allowed on the area.)

TABLE 5

Hunters per Thousand Acres

	Day of season										
	1	2	3	4	5	6	7	8	9	10	Season
Sartain 1947	112.4	84.4	58.8	12.3	13.1	11.4	14.2	11.7	29.6	26.6	374.5
1948	229.4	206.8	135.8	30.3	34.1	28.2	27.0	26.9	67.3	57.5	843.3
McManus 1947	85.3	62.8	66.8	7.0	8.7	7.8	16.7	5.1	19.6	24.6	304.4
1948	149.0	133.6	102.2	24.4	17.2	17.0	15.5	16.3	30.9	35.3	541.4

TABLE 6

Age Determination by Bursa Depth for 1947 and 1948 Hunting Seasons

	Adults		Intermediate		Young		Adults		Intermediate		Young	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1947	12	11.7	2	1.9	89	86.4	36	15.9	7	3.1	183	81.0
1948	11	4.1	3	1.1	252	94.7	41	13.4	9	2.9	257	83.7

There was no indication that the percentage of old birds in the kill had varied from the first days to the last days of the season. It has been suggested that old birds may be "wiser" than birds of the year. If such were the case the proportion of old birds in the kill should increase as the hunting season progresses and as the younger more easily shot birds are killed. Our results showed no variation in the ratio of old to young throughout the season on the heavily shot study areas.

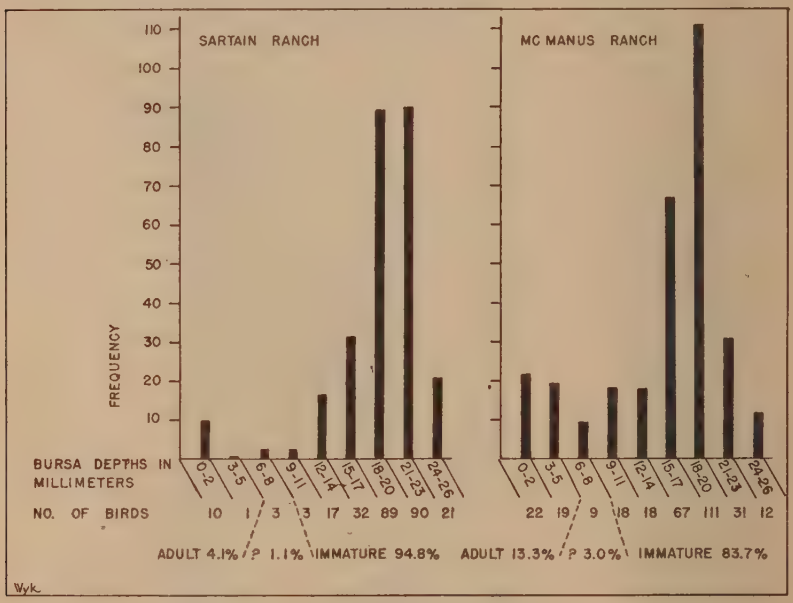


FIGURE 91—Frequency distribution of Bursa depths

However, other workers have obtained different results. Leopold reported in his studies on the Conaway Ranch that a greater proportion of young birds were taken the first part of the season than the last, see Table 7. Hunting pressure on the Conaway Ranch was approximately 25 acres per hunter during the 1948 season compared to 1.18 acres per hunter on the Sartain Ranch and 1.84 acres per hunter on the McManus area. Kimball (1948) working in the Dakotas reported results similar to Leopold. In the Dakotas hunting pressure is relatively moderate compared to the two study areas under consideration. It may be that whether

TABLE 7

Age Ratios Among Cock Pheasants From Conaway Ranch *

	1947		1948	
	Birds aged	Percent young	Birds aged	Percent young
Sample taken first five days of season	138	77.5	190	65.8
Sample taken last five days of season	88	67.0	96	57.3

* From Leopold 1949.

or not a seasonal kill pattern shows a higher percentage of young in the kill early in the season depends upon the degree of hunting pressure on any given area.

Weights

Birds were weighed from both of the study areas in 1948 and from the Sartain Ranch only in 1946 and 1947. Each season the average weight of those cock pheasants weighed has been 2 pounds, 11 ounces, a remarkable uniformity from year to year. During the period the heaviest bird brought to a checking station weighed 3 pounds, 9 ounces.

Average weights taken from a series of game farm birds in the kill shows that game farm stock averaged lighter, two pounds, eight ounces, for both the 1947 and 1948 seasons. However, an early hatched pen raised bird released in June of 1948 was the third largest bird weighed on the Sartain area for that season. The main kill of game farm birds occurs from groups planted nearest the hunting season, and these are late hatched birds. This probably explains in large part the lower average weights.

Returns From Game Farm Plantings

Stocking with game farm birds have been made only on the Sartain Ranch, the McManus area being unstocked. Table 8 shows a summary of the 1948 plantings plus the returns on the same. The six-, eight- and ten-

TABLE 8

Game Farm Bird Return on Sartain Releases

Age released	Number released (cocks)	Date of release	Days in field (before season)	Number of bands returned	Percent return
6 weeks	50	6/11/48	161	4	8
8 weeks	50	6/11/48	161	5	10
6 weeks	50	6/25/48	147	2	4
8 weeks	50	6/25/48	147	11	22
10 weeks	50	6/25/48	147	25	50
6 weeks	50	8/ 5/48	106	0	0
8 weeks	50	8/ 5/48	106	7	14
10 weeks	50	8/ 5/48	106	14	28
12 weeks	100	8/18/48	93	35	35
11 weeks	100	9/14/48	66	43	43
16 weeks	100	10/18/48	32	55	55
16 weeks	99	11/17/48	2	80	80.8
Totals	799			281	35

weeks age groups were stocked in order to get comparative return data on simultaneous plantings of different age groups. The remaining groups were used to measure return in relation to time spent in the field before the hunting season.

The six- and eight-weeks old birds were banded with wing bands and the ten-weeks and older birds with aluminum leg bands (size 14, .051 inch). However, the eight- and ten-weeks groups of the August plants (Table 8) were marked with both wing and leg bands. In five out of twenty-five returns from the ten-weeks old group and one out of seven from the eight-weeks old group it was found the wing band had remained

on the birds, whereas the leg band had been lost, indicating that some leg bands are lost and that wing bands may be a more permanent marker than leg bands, at least with ten weeks old birds and younger.

From a total of 799 pen-reared cock pheasants released on the Sartain Ranch 281 bands were returned, giving an over-all return of 35 percent for all ages released. Game farm stock made up 8.7 percent of the total kill on the Sartain area. Table 9 gives the percent of game farm birds and wild birds making up the daily and seasonal kill on the Sartain Ranch.

TABLE 9

Percent of Game Farm Birds and Wild Birds Making Up Daily and Seasonal Kill, 1948

	Daily percent										
Day of season	1	2	3	4	5	6	7	8	9	10	Season
Wild birds	90.7	91.3	94.6	90.6	87.5	90.9	87.5	98.5	91.2	91.4	91.3
Game farm birds	9.3	8.7	5.4	9.4	12.5	9.1	12.5	1.5	8.8	8.6	8.7

As shown in Table 8 the largest return was from birds of the ten- to sixteen-weeks age classes. Also, a decrease in return is noted in relation to time spent in the field before the hunting season. Figure 92 shows the percent return on four game farm bird releases in relation to the days in the field before the hunting season. From an 80.8 percent return from birds released two days before the season the return drops to 35 percent for birds in the field 93 days before the season.

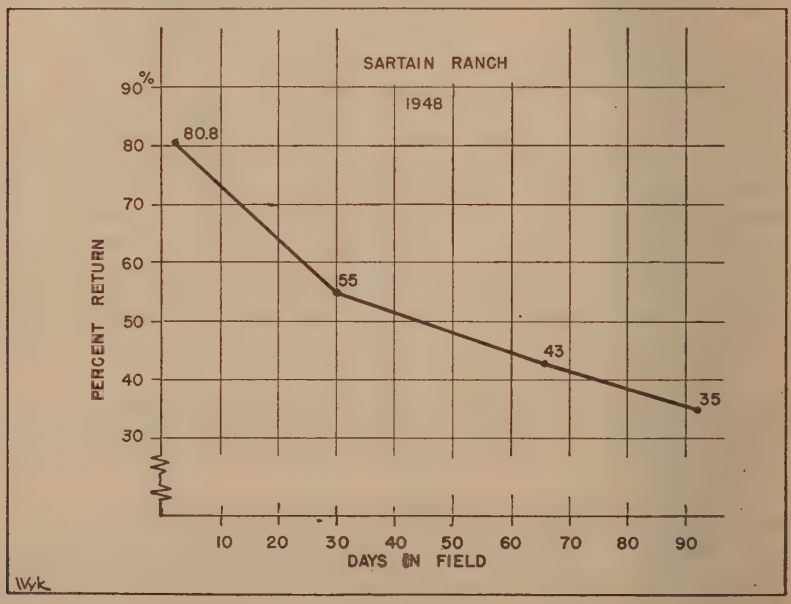


FIGURE 92—Percent return of game farm birds in relation to time in field, Sartain Ranch

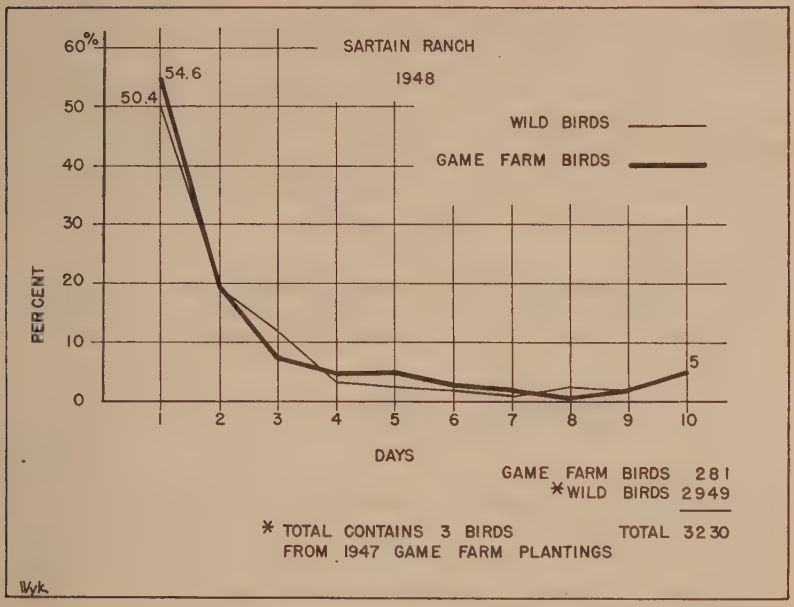


FIGURE 93—Daily percent of total seasonal wild bird kill and total seasonal game farm bird kill, Sartain Ranch

When six-, eight- and ten-weeks age groups were planted simultaneously the older birds produced the highest return. (See Table 8.)

It is of interest to note that the June 25th release gave a uniformly higher return than the August plant although these birds were in the field a little over a month longer (Table 8). This would indicate that possibly the conditions affecting the June plant were especially favorable.

The daily percent of the total seasonal wild bird kill and game farm bird kill remained remarkably parallel throughout the season. This seems to indicate that game farm birds are not killed by hunters any more readily than are wild birds on a heavily hunted area (Figure 93).

Returns From the 1947 and 1946 Sartain Plantings

In 1947, 300 cocks were planted in lots of 100 on September 10th, 11th, and 12th. During the same season in which they were released a 32.7 percent return was recorded while in 1948, the second season these birds were in the field, three birds or 1 percent were taken.

In 1946, 220 cocks four and one-half months of age were released on October 17th. These produced a 37.7 percent return the season they were released.

Effect of Game Farm Releases

A comparison of the kill on Sartain (planted, artificially stocked with game farm birds) and McManus (not planted with game farm stock) areas presents evidence that the released birds do not materially change the hunters' bag on a given area. The kill of wild birds on the Sartain area was 2,949.* This was only 293 more birds than were killed

* Total includes a return of three birds from 1947 game farm plants.

on the McManus area where no game farm birds were released. Part of this 293 can probably be attributed to the greater hunting pressure on the Sartain area.

In 1947, 500 hens were released on the Sartain area and in 1948, 560 hens were released. Obviously only the first 500 could have reproduced and contributed to the 1948 kill. Apparently the 500 hens released in 1947 made little difference in the comparative kill between the Sartain and McManus area during 1948. The effect of the 1948 hen plantings will not be known until the 1949 check is made.

Cock-hen Ratios

Preseason and postseason censuses for determining cock-hen ratios have been made on both study areas for the years 1947 and 1948. Hiking census procedure was used and the results are presented in Table 10.

TABLE 10

Cock-Hen Ratios (Expressed in Cocks per 100 Hens)

Area		Pre-season	Post-season
Sartain	1947	34.3	5.4
	1948	88.4	14.5
McManus	1947	37.0	9.6
	1948	70.2	10.4

Population Calculations

The approximate total populations of the Sartain and McManus areas can be computed by the use of the Kelker Index (1944) which used the sex ratio (number cocks per hen) before the season, the total kill including crippling loss of both cocks and hens, and the postseason sex ratio in the following formula:

$$\frac{b_b\,(K_D - K_B)}{b_a - b_b} = D$$

Where b_b = preseason sex ratio, b_a = postseason sex ratio, K_D = hen kill, K_B = cock kill, and D = postseason hen population, this can be expressed as follows:

$$\frac{\text{Preseason Sex ratio} \times (\text{hen kill} - \text{total cock kill})}{\text{Postseason sex ratio} - \text{preseason sex ratio}} = \text{Postseason hen population}$$

Postseason hen population + hen kill = preseason hen population.
Postseason hen population × postseason sex ratio = postseason cock population.
Postseason cock population + total cock kill = preseason cock population.

The crippling loss of cocks was estimated at 30 percent of the number of cocks bagged and the hen kill through illegal shooting was estimated at 5 percent of the number of cocks bagged.

Calculations for the Sartain Ranch, 1948 Season

The 80 cocks killed from the last plant of 99 game farm birds (released two days before the season) were not included in the total kill as they were not included in the preseason sex ratio.

$$\frac{.88 \times 158 - (3{,}150 + 945)}{.15 - .88} \times \frac{(-1)}{(-1)} = \frac{4{,}095 - .88 \times 158}{.88 - .15} = 5{,}419 \text{ hens postseason}$$

5,419 + 158 = 5,577 hens preseason.
5,419 × .15 = 813 cocks postseason.
813 + 4,095 = 4,908 cocks preseason.

Calculations for the McManus Area, 1948 Season

$$\frac{.70 \times 133 - (2{,}656 + 797)}{.10 - .70} \times \frac{(-1)}{(-1)} = \frac{3{,}453 - .70 \times 133}{.70 - .10} = 5{,}600 \text{ hens postseason}$$

$5{,}600 + 133 = 5{,}733$ hens preseason.
$5{,}600 \times .10 = 560$ cocks postseason.
$560 + 3{,}453 = 4{,}013$ cocks preseason.

A comparison of the total population of hens and cocks derived by Kelker calculations for the Sartain and McManus areas for 1947 and 1948 is presented in Table 11. The percent of kill of the total cock population was 85.5 in 1947 and 83.5 for 1948 on the Sartain Ranch. The McManus area percent of kill was 73.3 in 1947 and 86.1 in 1948.

TABLE 11

Total Populations on Sartain and McManus Areas for 1947 and 1948

	Number hens	Number cocks	Total	Number hens	Number cocks	Total
Sartain 1947	4,579	1,556	6,135	4,528	226	4,754
1948	5,577	4,908	10,485	5,419	813	6,232
McManus 1947	4,592	1,699	6,291	4,544	454	4,998
1948	5,733	4,013	9,746	5,600	560	6,160

DISCUSSION AND CONCLUSIONS

It has been shown in this study that Sacramento Valley pheasant habitat as typified by the areas of mixed rice and dry grain culture is capable of producing a high sustained yield of cocks to the hunters' bag. This high production, over 300 cocks per 1,000 acres, taken by hunters on the McManus area the 1948 season is possible under present agricultural practices without application of any management procedures such as stocking with game farm birds or altering the present habitat. Hunting pressure on the McManus area was 3.2 acres per hunter in 1947 and 1.8 acres per hunter in 1948. A large increase in pheasant population was noted on the study areas in 1948 and postseason censusing in 1948 revealed a sufficient number of cocks present even after a seasonal hunting intensity of one man for each 1.8 acres.

At present the acreage of land posted against trespass by hunters is many times the area of land open to hunting. Much of this posted land would produce a pheasant kill equally as good as the two study areas, but because of posting few or no birds are taken. It seems then that the management procedure of most urgency facing the California Division of Fish and Game is that of working out agreements with the landowners so that trespass for hunting purposes will be permitted.

Present informal relations between the Division of Fish and Game and the owners of the Sartain and McManus areas have been very satisfactory to all persons concerned. Legislation has now been enacted which will enable the State to negotiate for formal agreements opening farm land in good pheasant habitat to hunters. It is hoped that these agreements will work out satisfactorily so that the pheasants that are now being produced in goodly numbers under wild conditions will be made available to the hunter.

SUMMARY

Two study areas (Sartain Ranch, 6,920 acres, and McManus area, 7,800 acres) were set up in 1946 for investigations of the effect of heavy hunting pressure on wild established pheasant populations. They are located in the northern part of the Sacramento Valley on farming lands typical of the better pheasant habitat in California. Characteristic crops are rice, barley, and wheat. The two areas are separated by three and one-half miles of unirrigated grain land.

The 1948 hunting season showed a marked increase in number of hunters and in birds killed on both study areas over the 1947 season. In the three hunting seasons studied most of the hunting pressure and most of the kill occurred the first three days.

Large numbers of San Francisco Bay region sportsmen hunt the Sacramento Valley area. An airplane census of hunter vehicles showed a marked increase in hunting pressure in 1948, confirming checking station results.

Old-young ratio of the kill determined by measuring the depth of the Bursa of Fabricius showed that birds of the year make up the greatest percentage of the hunters' bag during any one season.

Pen-raised birds, both cocks and hens, were released on the Sartain study area in 1947 and 1948. In 1948 a return of 35 percent was recovered in the hunter bag from all ages released. This was 8.7 percent of the total kill on the Sartain Ranch. When simultaneous releases of six, eight, and ten weeks old birds were made the older age groups yielded the better return. Fall releases of 500 pen reared hens in 1947 on the Sartain ranch had no apparent effect on the 1948 hunting take.

Apparently pheasants are able to withstand heavy hunting pressure in the better habitat of the Sacramento Valley without benefit of stocking with pen-raised birds. The management procedure most urgently needed is a working agreement with landowners so that hunter access to the present populations of wild pheasants will be permitted on property currently posted against hunting trespass.

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THE CONTROL OF AVIAN TUBERCULOSIS IN A STATE GAME FARM[1]

By Merton N. Rosen[2] and Eugene D. Platt[3]
Bureau of Game Conservation
California Division of Fish and Game

INTRODUCTION

Fourteen years prior to the discovery of the tubercle bacillus by Robert Koch, Crisp, in 1868, described the occurrence of tuberculosis in chickens. Transmission of the disease in poultry was accomplished by Crisp in 1872. During the same year Paulicki observed tuberculosis in birds at the Hamburg Zoo. Crisp, in 1875, described the pathology of tuberculosis in 21 two-year-old pheasants. Along with the discovery of the cause of tuberculosis, Koch confirmed the occurence of the disease in poultry. The differentiation of tuberculosis into three forms: Human, bovine and avian was recognized by Koch in 1901.

Recognition of the serious character of avian tuberculosis as it affects poultry was not forthcoming until 1920 when the high incidence of infection in farm flocks was discovered. A great threat is still present in the North Central States where 75 percent of the poultry farms have the disease with its attendant high mortality, according to the U. S. Department of Agriculture (1942). This agency also reports that economically there is loss to the producer by decreased egg production and subsequent death of the fowl. The disease is easily transmitted to swine with the result that approximately $2,000,000 loss in condemned pork is suffered by the United States annually.

Tuberculosis in game birds can be a serious problem as it affects the management of game farms. Decreased egg production along with death increases the cost of pen-reared birds to the sportsman. Pheasants or chukars liberated with the disease present a potential threat to poultry and swine producers.

CAUSE AND EFFECT OF TUBERCULOSIS

The etiologic agent of avian tuberculosis is *Mycobacterium avium* (Chester). This bacillus is an acid fast organism that usually has a beaded appearance due to metachromatic granules. The rods are thin and slightly curved or straight. Growth on most media is slow, usually requiring four weeks; however, the senior author has obtained good growth in four to five days with Dubos' medium (Dubos 1945).

Mycobacterium avium may produce disease in all species of birds, and it is particularly virulent for chickens, pheasants, chukars, and

[1] Submitted for publication August, 1949.
[2] Federal Aid in Wildlife Restoration Act, California Project 35R.
[3] Late superintendent at the Yountville Game Farm.

turkeys. As the disease progresses within the bird there is a gradual loss of weight which game farm breeders term "going light." The emaciation is hidden for much of the course of the disease by the plumage, and only in the last stages can the affected bird be distinguished from normal fowl. Even when the pectoral muscles have practically disappeared and the keel bone is a thin anterior prominence, the wild nature of the pheasant may overcome any feeling of lassitude when approached by the game bird breeder, although its stamina is gone and the bird will become fatigued quickly.

Extensive pathology has been observed in pheasants and chukars. The liver is most frequently affected, having tubercles scattered about the tissue. These nodules may be miliary and hard to distinguish, or they may be large and well isolated usually measuring between five and ten millimeters in diameter, although much larger tubercles have been observed. The spleen may or may not show pathology. Several spleens have been seen that were ten times the normal size and consisted of one huge caseous necrotic mass. Tubercles may stud the intestinal wall. Ascites is a common pathological finding. All organs with the possible exception of those composed of nervous tissue, have been attacked by the organism according to Feldman (1938).

TRANSMISSION

Tuberculosis is a chronic disease when naturally induced, therefore it is difficult to trace the mode of transmission of this disease. In a large series of pens the continual appearance of tuberculosis year after year even though the pens are vacant during certain seasons lends support to the theory that the organism may be harbored in the ground. It is well known that the organism is highly resistant to inimical agents and Van Es and Olney (1935) demonstrated the lengthy viability of the virulent organism in an insanitary environment.

Contamination of food and water with infectious droppings would serve as a source of dissemination, but of greater importance would be coprophagy, a common fowl practice. Large populations within the restricted area of a small pen serves to saturate the environment with tenacious organsms so that eventually the soil and grit sought by gallinaceous birds may act as a continuous process of oral inoculation.

Roosters have been thought to transmit the disease to hens through coitus.

Schalk, Roderick, Foust and Harshfield (1935) incriminated pigeons and sparrows, rats and mice, but not earthworms as vectors of transmission of the bacilli. These vectors may be responsible for the spread of the disease but not to any great extent. Their primary importance would be the introduction of tuberculosis into healthy flocks.

ORIGIN

The introduction of tuberculosis at the Yountville Game Farm may be traced to one or more of four possibilities. The original procurement of the pheasant breeding stock was arranged through the State of Washington. No data is available as to the state of health or immediate subsequent mortality of pheasants during their introduction in 1925. During the following two years more pheasants were brought to the game farm

from Washington and Oregon. Wild turkeys were introduced to the game farm at the same time as the pheasants, but their source is unknown. Van Roekel (1929) observed tuberculosis at this same Yountville Game Farm in wild turkeys, but stated that the other species of birds at the game farm were less susceptible.

As the game farm started to expand its production immediately following the initial procurement of breeding stock of all game species, it became a customary procedure to exchange eggs with other states—including the central states—and to exchange chicks and poults with private breeders within the State. This exchange practice was continually carried on from the inception of the game farm until 1945 despite a notice in the *California Fish and Game* (1929, p. 244) that newly introduced birds constituted a likely source of disease.

In the earlier years of operation the game farm incubation was performed by use of domestic hens as foster mothers. The practice was to search the poultry farms of the countryside for "broody" hens, purchase them, and carry them back immediately to set on the pheasant eggs. This method probably accounted for the introduction of several poultry diseases and possibly tuberculosis.

Finally, quail were procured through trapping, thereby establishing the breeding stock. Frequently quail were trapped in areas where domestic poultry was raised.

DEVELOPMENT OF TUBERCULOSIS

Following Van Roekel's observation of tuberculosis in the turkeys no records are available for an accurate mortality rate of the disease. Personnel employed at the Yountville establishment submitted various estimates as to the morbidity and mortality rates. A concensus agree that from 1931 through 1936 losses in pheasants were not too heavy. There were some losses in turkeys, but blackhead occurred simultaneously with tuberculosis so that it is difficult to ascertain which disease was responsible for the deaths. Each season the fatality in pheasants was approximately 40 birds of a total population of about 1,800 breeding birds, or about 2.2 percent.

During the period 1937 to 1946 the mortality increased until there was an annual loss of between 100 to 200 pheasants of approximately 2,000 to 3,000 total population of breeding stock, or an average of 6.0 percent, with fluctuations reaching as high as 9.5 percent. Deaths due to tuberculosis were estimated at 90 percent of the mortality from all natural causes.

Coincident with the beginnings of increased death rate, a change in dietary practices at the game farm was instigated. Following the example of poultry producers, mash with a high protein content was used by the game bird breeders to force egg production. Highest morbidity was observed in the summer at the cessation of the breeding season. During the winter a gradual decline in the number of birds dying from tuberculosis coincided with the ration of grain supplanting the high protein diet. However, this was complicated by the release to the wild of the old breeding stock which would have added to the mortality figures as well as the morbidity totals during the winter. The personnel

concur in their observations that the disease was confined to breeding stock maintained for a second or third laying season.

The authors had occasion to investigate tuberculosis at the game farm beginning in 1946. At that time their observations substantiated the conclusions drawn by personnel actively engaged at Yountville over the previous 15 years. It had been the practice to reserve a series of 20 pens for the older breeding stock, and it was from these pens that the diagnosis of tuberculosis was most frequent. Adjoining the infected pens was a line of pens for chukar partridges. The chukars provided a large percentage of the total birds affected with tuberculosis.

CONTROL

A survey of tuberculosis in the poultry of the Central and North Central States by the U. S. Department of Agriculture disclosed that the large commercial flocks were relatively free of the disease as compared with domestic farm flocks. It was determined that it was a common practice to retain hens for a second or third or even fourth year in the farm flocks, whereas the large producers kept their poultry a maximum of 18 months. Since tuberculosis is a long chronic disease the incidence of infection could be materially reduced, and the transmission of the disease by infected birds considerably lessened through disposal of birds at 12 to 18 months of age.

Infected ground is a source of the disease when continually inhabited by a fowl population. Allowing pens to remain idle every other year provides a method by which the natural effect of sunlight can exert a bactericidal action. This is based on Koch's work in which he observed that human tubercle bacilli were killed by exposure to direct sunlight for two hours.

Abandonment of the policy of exchanging eggs or birds with other game farms removes the hazard of reintroducing tuberculosis within the confines of the game bird establishment.

In July, 1947, it was decided that pheasant breeding stock be released at the completion of the breeding season, and that birds of the year be selected for the following year of production. Further, that no birds be moved from one game farm to another inasmuch as Yountville Game Farm alone harbored tubercular pheasants. Finally, that those pens formerly reserved for older breeding stock remain vacant for a period of two years.

An accurate record of mortality was maintained following the start of the control program. All adult stock that died was autopsied and the cause of death ascertained.

As the present breeding season reaches completion no deaths from tuberculosis have occurred at the Yountville Game Farm in the last 13 months. This is the first annual record of freedom from tuberculosis in about 20 years.

Feldman observed that continuous exposure is necessary before an adult fowl can acquire the disease. By limiting the period of confinement of pheasants, the transmissability of the disease to birds released in the wild is lessened. Indeed the wide range of pheasants in their natural habitat is not conducive to the dissemination of tuberculosis among the game farm birds that have been liberated or to those birds that have existed continually in the wild.

The pens that were the site of high mortality from tuberculosis affecting both chukar partridges and pheasants have been dormant during the past two years. In order to test the efficacy of the control measures formulated and carried out, breeding stock two years old will be retained in those pens on an experimental basis.

SUMMARY

Avian tuberculosis was recognized by Crisp in 1868 and later described in pheasants. Koch described the causative organism and differentiated it from that of human and bovine tuberculosis.

The serious problem of this disease in game birds was established through the decrease in egg production and the high mortality. Tuberculosis causes extreme emaciation of the bird with extensive pathologic changes including liver, spleen, and intestinal tissue destruction.

Probably transmission of the disease occurs most frequently through the ingestion of food and water contaminated with infectious droppings, and by coprophagy. Tuberculosis is thought to have been introduced through the importation of infected birds or eggs, and by the use of domestic hens for incubation of pheasant eggs.

From 1931 through 1936, approximately 2.2 percent of the breeding population died from tuberculosis. During the period 1937 through 1946, the mortality increased to a high of 9.5 percent. Ninety percent of all mortality in adult breeding birds could be traced to tuberculosis. High mortality rates coincided with a high protein diet. The disease was limited to birds retained for a second and third laying season.

With the inception of the program that required liberation of the pheasants at the conclusion of their first breeding season, the Yountville Game Farm established an annual record of no mortality from tuberculosis for the first time in approximately 20 years. Through a lessened period of exposure and the dilution factor of the wild, liberated pheasants constitute a negligible threat to the free living population. Proof of the control measures is being established by submitting an experimental group of pheasants to maintenance over a prolonged period in pens formerly heavily contaminated with tubercle bacilli.

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NOTES

TAGGED FLATFISH RECOVERED AT EUREKA

Two flatfish that had been tagged by the Fish Commission of Oregon have been recovered by the Eureka trawler fleet. The first, a tagged petrale sole, *Eopsetta jordani,* was taken by the drag boat "Quest," captained by Albin Anderson, fishing for the Theo. Weissich Fish Company. The second flatfish, an English sole, *Parophrys vetulus,* was caught by one of the drag boats that fish for the A. Paladini Fish Company of Eureka, California.

The petrale sole was caught on November 21, 1948, while Captain Anderson was towing his drag net along the 200-fathom contour on the north slope of the Eel Canyon. This location is offshore from the Table Bluff Lighthouse. The total length was 489 mm., and the weight was 3.25 pounds. The specimen was a female with running eggs. Probably due to the rough treatment the drag net exerts on fish, the two plastic discs and the connecting pin were practically torn from the fish. The tags were sent to the Fish Commission of Oregon and Mr. George Harry, Aquatic Biologist, stated that this fish was tagged on April 28, 1948, south of the Columbia River in 40 fathoms. The length was 480 mm. Mr. Harry also remarked that this migration is the longest movement that has been recorded by their tagging program.

The other flatfish, the English sole, was discovered in an aggregate catch of several trawlers fishing for the A. Paladini Fish Company on January 28, 1949. All of these drag boats were operating in a small area southwest of St. George Reef in 30 to 40 fathoms. Marine Warden Walter Gray sent the data and tags to Oregon and Mr. Harry again replied that this female fish was tagged on August 18, 1948, in 20 fathoms off of the mouth of the Columbia River. The fish grew one-half inch in its migration south. This is the longest southerly migration of this species that has been observed under the tagging program Oregon has been conducting, according to Mr. Harry.—*Frederick B. Hagerman, Bureau of Marine Fisheries, California Division of Fish and Game, July, 1949.*

PIPEFISHES AND SEAHORSES AS FOOD FOR TUNA

It would seem unique if such small feeble-swimmers as the Syngnathids were to appear among the contents of tuna stomachs. Recently, however, several records have become available which may indicate that these fishes are not a rarity as tuna foods. The latest occurrence is that of a partially digested 42 mm. seahorse of yet undetermined species (Calif. Acad. Sci. No. 20388). This fish was taken from the stomach of a yellowfin tuna caught in the northern Hawaiian Islands by the M. V. "N. B. Scofield" during August, 1948. The stomachs were not opened until the tuna were returned to the California State Fisheries Laboratory at Terminal Island. The seahorse was found together with the usual juvenile surgeon fishes, trigger fishes and other small forms which are abundant as tuna foods.

This incident brings to mind a previous collection of pipefishes taken from the stomach of Philippine tuna *(Euthynnus yaito)* during 1948. A single specimen of *Halicampus grayi* was taken from a yaito stomach caught on January 7th, and 30 more pipefishes of the same species were taken from the stomachs of four yaito tuna on January 14th. The longest of these pipefishes was 70 mm. in length. All of the tuna were taken by trolling in the vicinity of Basilan Island in the Sulu Archipelago. The trolling was done from the U. S. Fish and Wildlife Service research vessel, the "S. F. Baird."

The seahorse may have been a casualty of indiscriminate feeding by yellowfin tuna, but the pipefishes in this instance cannot be considered as an accidental tuna food. It will be of interest to note that *Halicampus* has been taken on only one other occasion in the Philippines. It is probable that this pipefish is one which is abundant in deeper water and occurs rarely in shallow water.

During the reef fish investigations of Operation Crossroads conducted at Bikini and adjacent atolls it was discovered that some Syngnathids are sharply limited in vertical distribution and that those species which occurred in the intertidal area usually were not present at depths below 20 or 25 feet. In this deeper water a new series of species was to be found which was totally absent in the intertidal area. In fact five of these deep water types turned out to be entirely new to science. With diving gear one species proved to be a free-living form and was very abundant below depths of 20 feet. Tuna feeding in the area would have had no difficulty in picking off such choice tidbits as these small pipefishes.

It is suggested that when more is known of vertical distribution among fishes, this information may be useful in analysis of stomach contents to determine vertical feeding levels of the predator.—*Earl S. Herald, Steinhart Aquarium, California Academy of Sciences, San Francisco, California, July, 1949.*

RETIREMENT OF BRIAN CURTIS

Mr. Brian Curtis, Supervising Fisheries Biologist, retired on September 30, 1948, after eight strenuous years during which he supervised the organization and work of the biological staff of the Bureau of Fish Conservation.

Mr. Curtis first came to the division as a senior member of the new biological group that was being organized by the bureau in 1937. His previous background had included engineering work in South America and free-lance writing, which had led him to an interest in fisheries biology, and that in turn resulted in a thesis and degree at Stanford, with Golden Trout as his subject of graduate study.

Between 1937 and 1940 he served as biologist in the Tahoe area, as a start was then being made on the organization of the Bureau of Fish Conservation on a district basis. In December, 1940, Mr. Curtis was appointed to the newly created position of Supervising Fisheries Biologist. Even though his staff was reduced to three district biologists during the war years he was able to lay the foundation for the later rapid expansion of the group when manpower became available after the war ended. Great credit is due him for the organization and planning that later resulted in such effective work by the enlarged staff.

All within the division will miss the friendly help and judicious advice that Mr. Curtis so freely gave, and join in wishing him full and continued enjoyment of his new role of Napa Valley vineyardist.—*Alan Taft, Bureau of Fish Conservation, California Division of Fish and Game, July, 1949.*

RETIREMENT OF C. S. BAUDER

Charles S. Bauder retired from state service with the Division of Fish and Game on June 30, 1949, having reached the age requirement for patrol service.

Bauder was appointed a deputy on October 1, 1914, and on June 30, 1949, had completed nearly 35 years of service.

Bauder was promoted to Assistant Chief of Patrol in 1927. He served in this capacity in the Los Angeles district until 1941, when he was transferred to the Sacramento office until time of retirement.

Assistant Chief Bauder has completed one of the longest terms of service in the Bureau of Patrol, and was highly regarded as an administrator.

Our sincere wishes go to Charley for a happy and enjoyable retirement.—*L. F. Chappell, Bureau of Patrol, California Division of Fish and Game, August, 1949.*

RETIREMENT OF CLIFF S. DONHAM

After 25 years of service with the Division of Fish and Game, Cliff S. Donham retired June 30, 1949, having reached the retirement age for wardens.

He was appointed a deputy in 1924, and fish and game warden in 1931. Prior to this time, he was a deputy sheriff in Riverside County. Most of his service with the division was in Southern California, Riverside and San Bernardino Counties, where he was very highly regarded as an efficient officer.

Best wishes go to Cliff Donham for a long and happy retirement.—*L. F. Chappell, Bureau of Patrol, California Division of Fish and Game, August, 1949.*

RETIREMENT OF CARLOS O. FISHER

We regret to announce the voluntary retirement of Warden Carlos O. Fisher, which occurred on May 4, 1949. Warden Fisher had been ill for some time prior to retirement. We had all hoped that he would recover sufficiently to continue his duties. His physician, however, advised that he could not safely return to warden work.

Carl Fisher was appointed a deputy in 1919, and had served as a patrol officer for nearly 30 years. He was highly respected, an efficient officer, and will be greatly missed by the bureau. He was a veteran of World War I, and received injuries in this service. Most of his service with the division was in the Sacramento district and Northern California.

We sincerely wish that Carl will make a rapid recovery and be able to enjoy the fruits of a well-earned retirement.—*L. F. Chappell, Bureau of Patrol, California Division of Fish and Game, August, 1949*

RETIREMENT OF CHARLES SIBECK

Having reached retirement age for warden service, Charles Sibeck was retired from state service June 30, 1949.

Sibeck was appointed a deputy in 1925, and a fish and game warden in 1931. All of his work with the division was performed in the Sacramento area and northern part of the State. He was a tireless worker; hours meant nothing to him in the job of enforcing the fish and game laws. Hunting and fishing is his avocation, and we sincerely hope now that he has been relieved of the duties of a patrol officer, that he may enjoy this activity for many years.

The best wishes go to Warden Sibeck from the Bureau of Patrol and the Division.—*L. F. Chappell, Bureau of Patrol, California Division of Fish and Game, August, 1949.*

IN MEMORIAM
ARTHUR STAGER

Captain Arthur Stager met death by drowning on October 28, 1948, while on patrol duty on Fall River, near Glenburn, Shasta County. The skiff which Stager was using capsized; and heavy clothing and cold water were probably accountable for his inability to reach shore, as he was regarded as a good swimmer.

Warden William Hoskins accompanied him, but was on shore some 150 yards away when the accident occurred. He secured another boat and went to Stager's assistance, but when he reached the spot Stager had disappeared. Hoskins located the body in about five feet of water and near shore. He succeeded in getting the body ashore and applied artificial respiration. Help was summoned, together with a doctor from Fall River Mills, who pronounced Stager dead.

Arthur Stager entered service with the division as an assistant fish and game warden in 1936. He was promoted to a regular warden in 1938, and a captain of patrol in 1947. He was a veteran of World War II.

Stager's work with the division had been principally in the southern patrol district, where he had an outstanding record as a warden. Upon his promotion to captain, he was transferred to the Redding district. He had served in this capacity slightly less than a year when the accident occurred.

Stager was very highly regarded by the bureau and his fellow workers in the division. He leaves a son, father and mother, and several brothers and sisters to whom we extend our sincere sympathy.—*L. F. Chappell, Bureau of Patrol, California Division of Fish and Game, August, 1949.*

IN MEMORIAM
EUGENE D. PLATT

Eugene D. Platt, superintendent at the State Game Farm at Yountville, passed away near Newport Beach on July 11, 1949. He was born April 17, 1898, and received his high school education at Claremont, California.

Gene was appointed to the Division of Fish and Game in 1926 and was superintendent of the Chino Game Farm from 1929 to September 1, 1946, at which time he took over the duties of superintendent at the Yountville Game Farm.

He was one of the best-liked of division employees. His disposition and fine sense of humor endeared him to all with whom he came in contact. Many of the present staff of the Bureaus of Patrol and Game Conservation received their first introduction and their early training under his guidance. A large portion of the present personnel owe their position and success to the encouragement and coaching on details obtained under Gene's direction or through further contact with him. He enjoyed visiting with his former boys whenever he had an opportunity in the field and their informal discussions with him undoubtedly carried much weight in important decisions required of them. He was in constant correspondence with many of the boys while they were in military service. He leaves his widow, a daughter and a son, to whom we express our deepest sympathy.—*Fred Hein, Bureau of Game Conservation, California Division of Fish and Game, August, 1949.*

REVIEWS

The Life Story of the Fish. His Morals and Manners

By Brian Curtis; Harcourt, Brace and Company, New York, 1949; 284 pp.; $3.75.

Since the rewritten edition of the volume appeared a few months ago it has been reviewed in almost every journal and newspaper. All reviews have been enthusiastic. All have pointed out that Mr. Curtis has written a very charming, a very entertaining book for the fisherman, the aquarist, and the intelligent layman with an inquiring mind. However, I have seen no reviews which have commented at length on the new chapter which Mr. Curtis has added. Perhaps this has been left intentionally to California Fish and Game for it is the readers of this journal who should be most concerned. Mr. Curtis was Supervising Fisheries Biologist of California's Bureau of Fish Conservation and also editor of this journal for several years.

Chapter XI, "Fish and Fishermen," is an ambiguous title. The author may have wanted to call it "The Role of the Biologist in Sustaining the Yield of Fish," but obviously this would have frightened the gentle reader. No publication for "lay" consumption has so adequately portrayed the need of biological studies in fisheries management, and the author has done the professional fish biologist a very real service. If the reviewer had his way, this book—particularly Chapter XI—would be recommended reading for all enthusiastic members of sportsmen's clubs.—*J. H. Wales, California Division of Fish and Game.*

Mammals of Lake Tahoe

By Robert T. Orr, San Francisco; California Academy of Sciences, 1949; 127 pp., 37 line cuts, 1 map; $4.

For the use of those whose interest is centered in the Lake Tahoe area, the author has provided a very useable text covering the principal mammals of the region. Excellent, brief introductory passages relate to the reader the history of the region and its description in which the significance of biological factors in controlling the distribution of a species is brought out. Methods of classification are explained and a key to identification is included which, for the general purpose of the book, is probably superfluous. The excellent line drawings by George and Patritia Mattson will amply suffice for most readers in making their identifications. The material used is accurate and well written, but very little is included that has not already appeared elsewhere in print. The text is essentially a condensation to fit the area in question.

The average reader will probably find the glossary of terms quite useful. For further reading a short reference list of well-chosen texts is included.—*Gordon L. Bolander, California Division of Fish and Game.*

Man on the Landscape

By Vernon Gill Carter, National Wildlife Federation, Washington, D. C., 1949. 129+xv pp., 53 figs.; $1.50.

The author has made a sincere attempt at producing a textbook on soil and habitat conservation which should be required reading for all students pursuing natural science courses. The urgent necessity of conserving all of our natural resources by utilization with an eye to a productive future is the central theme. Important points are printed in eye-catching boldface type and repetition is frequent throughout the text for emphasizing the basic points. Experiments and presentation suggestions are included in the appendix which follow the chapter arrangements of the text.

While the author implies that the book is designed for the high school level, it is felt that more utility can be derived by students of the college level. However, those desiring to pursue the subject further will be handicapped by the lack of a bibliography, references being presented as footnotes throughout the text.

The reading flows rather smoothly, the author having injected some excellently pointed humor, but some portions drag, taking the book out of the pleasure-reading category for the casual reader. When read as intended by the author, the text fills an important gap in conservation education. The copious supply of excellent photographs admirably complements the text. The single chart depicts the hydrologic cycle in a simple and bold manner, while neatly summarizing this important phase.

The presentation of material is rather timely in view of the recent controversies in regard to conservation of our natural resources.—*Henry A. Hjersman, Bureau of Game Conservation.*

REPORTS

FISH CASES

April, May, June, 1949

Offense	Number arrests	Fines	Jail sentences
Angling: Blocking stream; 2 poles, near dam; netting; at night; no lic. transfer of license; illegal seining; possession spear; back dating license; near dam	566	$8,860 00	2 days
Abalones: Undersize; overlimit; out of shell; no license	226	6,238 00	
Sea bass: Sale undersize	1	25 00	
Chumming:	11	175 00	
Crabs: Fail to show on demand	1	10 00	
Perch: Closed season	1	25 00	
Bluegill: Other than angling; closed season	9	260 00	
St. Bass: Set lines; resisting arrest; on commercial boat; sale; at night	140	5,561 20	150 days
Black Bass: Closed season	6	185 00	50 days
Sunfish: Closed season	6	150 00	
Clams: Overlimit; undersize	71	2,120 00	90 days
Scallops: Overlimit	1	10 00	
Shad: No license	4	40 00	
Trout: Closed season; set lines; closed stream	147	6,374 00	
Salmon: Snagging; closed season; at night; mutilation	6	425 00	
Cockles: Overlimit, undersize	26	305 00	
Catfish: Undersize; no license	27	695 00	
Sturgeon: Possession	1	12 00	
Lobster: Undersize	5	150 00	
Carp: Closed season; fyke nets	2	300 00	
Yellowfin: Sale undersize	2	300 00	
Crappie: Overlimit	2	60 00	
Frogs: Closed season	29	675 00	
Rock bass: Overlimit	4	125 00	
Barracuda: Overlimit	2	25 00	
Commercial: No license; gill net closed area; fail to submit records; fail to register boat; undersize sardines	28	1,035 00	30 days
Pollution: Oil, copper sulphate; fish refuse	13	1,775 00	
Totals	1,337	$35,915 20	322 days
Court forfeitures: (Confiscated fish)		$3,195 00	

GAME CASES

April, May, June, 1949

Offense	Number arrests	Fines	Jail sentences
Coots: Closed season	1	$50 00	
Elk: Possession	1		365 days
Deer: Doe; closed season; spike buck; possession fawn; allow dogs to run	21	1,560 00	
Deer meat: Closed season	29	2,700 00	
Doves: Closed season; poisoning	8	325 00	
Mudhens: Closed season	1	50 00	
Pheasants: Hen; closed season	27	2,800 00	
Ducks: Closed season; illegal import	1	825 00	
Geese: Closed season	1	50 00	
Pigeons: Closed season	19	965 00	
Quail: Trapping; closed season	9	430 00	
Rabbits: Snaring; closed season	25	675 00	15 days
Squirrels: Possession tree squirrel	2	100 00	
Shorebirds: Possession curlew	1	14 00	
Non-Game: Possession	3	50 00	
Hunting: In refuge; late; from motor boat; spotlighting; no license	34	2,030 00	
Totals	183	$12,624 00	380 days

SEIZURES OF FISH AND GAME

April, May, June, 1949

Fish:

Abalone	1,958
Clams	1,316
Cockles	7,066
Octopus	1
Bass	740
Bass, pounds	21
Bluegill	177
Crappie	36
Crappie, pounds	8
Sunfish	160
Sunfish, pounds	8
Sturgeon	1
Trout	955
Frogs	150
Catfish	357
Catfish, pounds	25
Lobsters	10
Lobsters, pounds	24
Salmon	13
Rock bass, barracuda	134
Perch	9
Scallops	128
Yellowfin, pounds	8,298
Rockfish	64
Shad	5
White sea bass, pounds	250
Sardines, pounds	85,200

Game:

Deer	9
Elk	1
Deer meat, pounds	280
Pheasants	36
Quail	26
Coot	2
Rabbits	36
Pigeons	50
Ducks	22
Doves	19
Geese	4
Squirrels	1
Non-game	3

DIVISION OF FISH AND GAME
STATEMENT OF EXPENDITURES
For the Period July 1, 1948, to June 30, 1949

Function	Salaries and wages	Operating expenses	Equipment	Totals
Administration:				
Executive	$12,080 65	$9,644 16		$21,724 81
Library	3,974 51	573 61	$757 36	5,305 48
Office—San Francisco	18,927 64	52,622 95	447 91	71,998 50
Office—Sacramento	28,579 30	111,458 05	1,628 74	141,666 09
Office—Los Angeles			34 93	34 93
Office—Redding	1,871 55	1,048 42	992 98	3,912 95
Office—Fresno	2,206 51	4,391 14	393 25	6,990 90
Office—Alturas		10 50		10 50
Office—Bishop		78 17		78 17
Office—San Bernardino	211 65	29 59		241 24
Office—Eureka				
Undistributed		3,169 43		3,169 43
Totals, Administration	$67,851 81	$183,026 02	$4,255 17	$255,133 00
Patrol and Law Enforcement:				
Air Patrol:				
Fairchild	$5,190 05	$120 38	$1,239 82	$6,550 25
Beachcraft	4,103 00	—431 64	1,105 67	4,777 03
Totals, Air Patrol	$9,293 05	—$311 26	$2,345 49	$11,327 28
Headquarters	$18,317 15	$7,051 86	$4,035 86	$29,404 87
Land Patrol:				
North Coast District	$146,815 00	$30,960 79	$14,030 89	$191,806 68
Northeast District	55,075 46	13,596 12	405 95	69,077 53
North Valley District	105,344 89	22,777 16	5,953 62	134,075 67
South Valley District	91,380 91	21,163 55	4,450 69	116,995 15
South District	153,330 54	31,920 87	9,236 40	194,487 81
Total, Land Patrol	$551,946 80	$120,418 49	$34,077 55	$706,442 84
Marine Patrol:				
Supervision and Cannery Inspection	$56,764 14	$9,999 52	$5,193 93	$71,957 59
Broadbill	3,794 00	1,469 36		5,263 36
Perch	5,203 00	5,412 88	772 22	11,388 10
Tuna	6,708 00	8,822 79		15,530 79
Tyee	2,253 00	759 42		3,012 42
Yellowtail	4,131 00	3,601 15	618 77	8,350 92
Small Boats (under 22')	10,275 00	6,077 01	1,222 38	17,574 39
Skipjack	4,131 00	3,867 23	468 05	8,466 28
Grunion	4,700 00	1,262 69	507 73	6,470 42
Bluefin	12,897 87	14,966 11	2,778 70	30,642 68
Marlin	10,018 63	9,818 77	445 93	20,283 33
Albacore	15,144 26	11,269 22	871 25	27,284 73
Shore Patrol	55,154 52	12,172 80	1,118 06	68,445 38
Rainbow	2,818 00	2,255 02	662 92	5,735 94
Undistributed		147,649 95		147,649 95
Totals, Marine Patrol	$193,992 42	$239,403 92	$14,659 94	$448,056 28
Totals, Bureau Patrol and Law Enforcement	$773,549 42	$366,563 01	$55,118 81	$1,195,231 27
Marine Fisheries:				
Headquarters	$39,209 53	$15,780 77	$3,390 04	$58,380 34
Library	3,444 54	961 33	532 56	4,938 43
Fish Investigation—Bottom Fisheries	8,569 76	3,299 10	6,940 43	18,809 29
Fish Investigation—Mackerel	13,612 33	2,341 91	759 59	16,713 83
Fish Investigation—Minor Investigation	585 33	997 15	103 38	1,685 86
Salmon	37,862 69	25,121 05	9,634 82	72,618 56
Sardines	21,691 33	2,194 52	2,120 03	26,005 88
Screens and Ladders	195 00	2,982 45		3,177 45
Seismic Survey Observations	3,265 79	2,172 87		5,438 66
Shellfish	6,157 00	739 53	48 04	6,944 57
Sport Fishery	6,605 00	562 22		7,167 22
Tuna	7,471 87	442 63	180 55	8,095 05
Undistributed—Freight, Cartage and Express		6,820 80	1,625 50	8,446 30
Statistics	55,113 76	14,644 40	2,059 10	71,817 26
Research Vessel—"N. B. Scofield"	30,754 42	24,097 89	869 96	55,722 27
Research Vessel—"M. V. Yellowfin"	16,171 01	9,552 18	1,001 16	26,724 35
Striper	345 80	23 35		369 15
Undistributed, Autos		9,959 46		9,959 46
Totals, Marine Fisheries	$251,055 16	$122,693 61	$29,265 16	$403,013 93

DIVISION OF FISH AND GAME

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1948, to June 30, 1949

Function	Salaries and wages	Operating expenses	Equipment	Totals
Fish Conservation:				
Biological Survey (see list following Hatcheries)	$89,678 08	$23,448 08	$25,985 94	$139,112 01
Headquarters	36,071 73	5,464 86	3,640 55	45,177 14
Fish Screens and Stream Improvement	17,044 28	7,032 95	1,581 89	25,659 12
Hatcheries (see list following)	383,920 39	206,544 30	78,422 48	668,887 17
Undistributed		165,199 35		165,199 35
Totals, Fish Conservation	$526,714 48	$407,689 54	$109,630 97	$1,044,034 99
Hatcheries:				
Alpine	$6 67	$63 05		$69 83
Basin Creek	9,086 19	1,760 29	$2,524 57	13,371 05
Benbow Dam Experimental Station	2,111 01	25 16		2,136 17
Brookdale	9,090 00	2,041 94	42 55	11,174 49
Burney	7,991 00	1,619 49		9,610 49
Cedar Creek		105 47		105 47
Central Valleys	18,637 92	10,144 64	20,965 06	49,747 62
Crystal Lake	10,066 53	3,930 41	6,623 03	20,619 97
Fall Creek	3,337 00	538 61		3,875 61
Feather River	6,376 98	971 05	1,280 88	8,628 91
Fillmore	28,887 51	16,398 14	3,202 14	48,487 79
Hot Creek	32,510 07	38,901 93	8,457 21	79,869 21
Huntington Lake	1,106 00	584 70		1,690 70
Kaweah	8,578 68	1,996 18	1,929 24	12,504 10
Kern	11,338 60	6,983 81	2,571 57	20,893 98
Kings River	9,085 26	2,571 57	3,734 41	15,391 24
Lake Almanor	11,953 00	3,067 39	3,510 42	18,530 81
Little Walker Lake Egg Collection Station	170 00			170 00
Madera	6,080 15	1,134 58		7,214 73
Miscellaneous Egg Collection Stations	5,161 62	919 06		6,080 68
Mt. Shasta	63,112 31	14,875 15	9,028 19	87,015 65
Mt. Tallac	5,917 65	2,178 61	1,366 41	9,462 67
Mt. Whitney	35,664 59	39,772 53	4,218 83	79,655 95
Moorehouse Springs	1,620 68	270 79		1,891 47
Mojave River	6,905 00	6,995 46	34 55	13,935 01
Prairie Creek	8,801 01	3,108 94	631 73	12,541 68
Sequoia	7,519 00	3,003 47	1,119 04	11,641 51
Tahoe	8,789 80	5,636 19	1,881 19	16,307 18
Whittier	13,057 03	31,794 51	2,478 34	47,329 88
Yosemite	9,861 99	1,633 13	4,073 03	15,568 15
Yreka Warehouse		—70 53		—70 53
Yuba River	5,719 77	283 52		6,003 29
East Side Reservoir	2,360 00	241 07		2,601 07
Hatchery Supervision	33,017 26	3,063 99	—1,249 91	34,831 34
Totals, Hatcheries	$383,920 39	$206,544 30	$78,422 48	$668,887 17
Biological Survey:				
Mt. Whitney	$9,752 41	$991 22	$310 50	$11,054 13
Southern	11,689 71	3,791 17	3,536 30	19,017 18
Striper		377 07	123 48	500 55
Mt. Shasta	13,816 12	2,527 04	3,061 55	19,404 71
Mt. Lassen	7,674 43	1,608 36	2,846 64	12,129 43
Tahoe	7,336 54	2,521 60	4,118 01	13,976 15
Central	16,944 58	7,785 90	10,718 59	35,449 07
Coast	9,678 27	1,290 50	81 25	11,050 02
San Joaquin	12,786 02	2,555 22	1,189 62	16,530 86
Totals, Biological Survey	$89,678 08	$23,448 08	$25,985 94	$139,112 01
Game Conservation:				
Headquarters and Supervision	$93,051 41	$—6,055 38	$26,963 99	$113,960 02
Game Farms (see list)	150,577 81	62,485 62	11,837 01	224,900 44
Game Management (see list)	111,074 65	126,074 96	21,371 56	258,521 17
Predatory Animal Control—				
Game Management Statewide	120,596 61	17,544 66	19,745 75	157,887 02
Sierra District	1,023 00	302 45		1,325 45
East South California District	10,260 97	5,604 97	1,291 49	17,157 43
Statistics		15,013 45	16,094 33	31,107 78
Undistributed		94,480 49		94,480 49
Totals, Game Conservation	$486,584 45	$315,451 22	$97,304 13	$899,339 80

DIVISION OF FISH AND GAME

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1948, to June 30, 1949

Function	Salaries and wages	Operating expenses	Equipment	Totals
Game Farms:				
Bakersfield	$3,109 99	$1 53		$3,111 52
Brawley	8,358 32	3,901 25	$2,172 50	14,432 07
Castaic	2,709 00	1,803 96	1,699 63	6,212 59
Chico	12,943 87	2,558 59	13 27	15,515 73
Fresno	12,607 86	9,103 06	466 20	22,177 12
Los Banos	7,196 20	1,144 60	53 46	8,394 26
Los Serranos	21,422 12	7,531 52	2,556 79	31,510 43
Marysville	7,658 53	1,547 19	100 86	9,306 58
Porterville	5,965 17	2,544 55	61 00	8,570 72
Redding	5,947 23	3,363 46	578 36	9,889 05
Sacramento	7,570 15	3,518 01	1,472 89	12,561 05
Stockton	724 34			724 34
Ukiah	603 34	35 87		639 21
Valley Center	5,374 00	2,321 17	177 80	7,872 97
Willows	4,626 99	2,760 60	1,933 09	9,320 68
Yountville	43,760 70	20,350 26	551 16	64,662 12
Totals, Game Farms	$150,577 81	$62,485 62	$11,837 01	$224,900 44
Game Management:				
Central California	$7,340 50	$2,302 26	$1,710 17	$11,352 93
Doyle Winter Range	3,826 01	719 03	176 24	4,721 28
Elk Refuge	5,948 57	1,180 95	451 48	7,581 00
Grey Lodge Refuge	8,881 62	2,605 60	6,259 32	17,746 54
Honey Lake Development	12,132 90	2,814 49	6,164 22	21,111 61
Imperial Public Shooting Grounds	4,057 36	7,172 68	107 83	11,337 87
Imperial Refuge	2,974 98	976 53	449 86	4,401 37
Interstate Deer Herd	3,197 00	479 42	35 61	3,712 03
Kettleman Hills Quail Refuge	5,564 00	782 48	90 00	6,436 48
Los Banos Refuge	6,933 90	2,662 95	3,415 13	13,011 98
Madeline Plains Wildfowl Development	11,941 19	1,905 03	1,622 56	15,468 78
Northeast California	4,262 00	919 93	164 76	5,346 69
Quail Management Desert Areas	4,844 33	737 28		5,581 61
Southern California	9,035 00	2,390 40	156 97	11,582 37
Southern Coast of California	4,762 00	1,159 48	177 95	6,099 43
Suisun Refuge	8,282 90	1,972 25	203 29	10,458 44
Tehama Winter Range	5,004 40	813 71	186 17	6,004 28
Heavy Equipment Pool	2,085 99			2,085 99
Undistributed		94,480 49		94,480 49
Totals, Game Management	$111,074 65	$126,074 96	$21,371 56	$258,521 17
Licenses:				
Salaries and Wages	$43,961 92			$43,961 92
Operating Expense		$37,804 72		37,804 72
Equipment			$225 45	225 45
Total Licenses	$43,961 92	$37,804 72	$225 45	$81,992 09
Administration—Conservation, Education and Public Information:				
Supervision	$15,453 88	$50,999 58	$3,211 69	$69,665 15
Exhibits	565 00	1,340 17		1,905 17
Undistributed		614 78		614 78
Totals	$16,018 88	$52,954 53	$3,211 69	$72,185 10
Reimbursement Maintenance Deduction				—24,947 54
Totals, Fish and Game Support 1948-49 fiscal year				$3,926,483 10
Contributions to State Employees' Retirement Fund				239,960 86
Other Current Expenses: Game Management (in cooperation with the Federal Government as provided by the Pittman-Robertson Act)				346,724 44
Reimbursement from Federal Government pro rata share Pittman-Robertson Act				—226,030 01
Net Total, Pittman-Robertson Act				$120,694 43
Special Claim for Secretaries of State Board of Control				436 00
Totals, Other Current Expenses				$121,130 43

DIVISION OF FISH AND GAME
STATEMENT OF EXPENDITURES—Continued
For the Period July 1, 1948, to June 30, 1949

Function	Salaries and wages	Operating expenses	Equipment	Totals
Capital Outlay:				
Construction, Improvements, Repairs and Equipment—				
Administration—				
Office Buildings—Redding and Alturas				$2,745 56
Miscellaneous Improvements to Land and Buildings				1,709 73
Lighting Improvements—San Francisco Office				3,750 00
Sacramento				823 75
Totals, Administration				$9,029 04
Fish Conservation—				
Rushcreek Road Improvement				$2,905 25
Fall Creek Building Improvement				229 53
Fillmore Hatchery				58,055 27
Mt. Whitney Hatchery				49,222 82
Kern Hatchery				643 89
Central Valley Hatchery				5,457 91
Hot Creek Hatchery				73,974 33
Whittier Hatchery				120 43
Fresno Hatchery				43 10
Mt. Shasta Hatchery				3,960 00
Burney Hatchery				536 00
Lake Almanor				142 71
Mt. Tallac Hatchery				1,731 55
Prairie Creek Hatchery				161 88
Madera Hatchery				532 20
Black Rock Hatchery				1,792 50
Mojave Hatchery				3,710 09
Yosemite Hatchery				9,611 87
Kaweah Hatchery				1,556 08
Sequoia Hatchery				8,318 66
Totals, Bureau of Fish Conservation				$222,739 07
Bureau of Game Conservation—				
Madeline Plains Waterfowl Development				$9,996 33
Tehama Winter Range				2,752 22
Poe Unit				459 16
Suisun Refuge				768 06
Los Banos Refuge				1,055 89
Grey Lodge Refuge				13,042 79
Food Habits and Disease Laboratory				353 02
Los Banos Game Farm				626 88
Los Serranos Game Farm				2,622 36
Yountville Game Farm				6,660 02
Honey Lake Refuge				7,113 43
Tupman Elk Refuge				1,605 75
Brawley Game Farm				1,448 49
Castaic Game Farm				970 19
Chico Game Farm				2,632 22
Marysville Game Farm				1,020 62
Porterville Game Farm				984 45
Redding Game Farm				1,999 58
Sacramento Game Farm				1,119 34
Willows Game Farm				1,688 27
Fresno Game Farm				6,222 26
Berkeley Laboratory				757 22
Imperial Refuge				2,388 01
East Side Reservoir				1,980 17
Miscellaneous				2,549 76
Totals, Bureau of Game Conservation				$74,767 50
Patrol and Law Enforcement—				
Offshore Vessel—Marlin				$19,724 62
Patrol Boat—Bluefin				805 83
Patrol Boat—Albacore				3,675 82
Inland Vessel Unit No. 1				6,266 98
Inland Vessel Unit No. 2				6,629 19
Totals, Patrol and Law Enforcement				$37,102 44

DIVISION OF FISH AND GAME
STATEMENT OF EXPENDITURES—Continued
For the Period July 1, 1948, to June 30, 1949

Function	Salaries and wages	Operating expenses	Equipment	Totals
Bureau Marine Fisheries				
Terminal Island—Remodeling of Laboratory				$520 26
Terminal Island—Alterations to Buildings				2,240 00
Terminal Island—Research vessel Yellowfin				78,601 68
Terminal Island—Research Vessel				2,500 00
Fish Screens Experimental Electrical and Mechanical				1,500 00
Tahoe Hatchery—Repairs and Painting of Buildings				968 00
Totals, Bureau Marine Fisheries				$86,329 94
Total—Capital Outlay				$429,967 99
Total Fish and Game Preservation Fund 1948/49 (excluding Marine Fisheries Research)				$4,717,542 47

DIVISION OF FISH AND GAME
STATEMENT OF EXPENDITURES—Continued
For the Period July 1, 1948, to June 30, 1949

Function	Totals
Wild Life Restoration Fund:	
Construction, Improvements, Repairs and Acquisitions	
Fillmore Hatchery Experimental Farms, etc.	$9,775 05
Crystal Lake	3,748 48
Quail Development, Southern California	12,018 35
Madeline Plains Water Fowl Development	15,351 66
Coast County Quail Development	611 20
Quail Development Valley Game Farm	2,467 25
Quail Development Marysville Game Farm	1,482 82
Quail Development Porterville Game Farm	2,129 70
Quail Development Chico Game Farm	4,303 82
Deer Creek Fish Screens	2,440 12
Quail Development Honey Lake	6,394 41
Merced River Fish Ladder	2,496 00
Kern River Hatchery	27,677 19
Quail Development Doyle Winter Range	2,487 67
Cedar Creek Hatchery Land Acquisition	5,000 00
Darrah Springs Hatchery	714 79
Moorhouse Spring Hatchery	21,167 05
Genevieve Lake—Check Dam on Meeks Creek	137 62
Stoney Ridge Lake—Check Dam on Meeks Creek	97 16
Total, Construction, Improvements, Repairs and Acquisitions	$120,500 34
Administration:	
Salaries and Wages	16,530 29
Operating Expenses including Technical Reports	31,081 05
Equipment	24 88
Total, Administration	$47,636 22
Total Wildlife Restoration Fund	$168,136 56
General Fund:	
Pacific Marine Fisheries Commission	$11,000 00
Marine Research Committee:	
Technical Reports	
Availability of Sardines	$2,559 43
Behavior and Physiology of California Sardines	5,000 00
Fish & Wildlife Service—Recruitment of Sardines, causes for Fluctuation and Oceanographic Conditions in Waters North of California	56,186 27
Travel	519 34
Total, Marine Research Committee	$64,265 04

DIVISION OF FISH AND GAME
STATEMENT OF REVENUE
For the Period July 1, 1948, to June 30, 1949

Revenue for Fish and Game Preservation Fund:			
1949 Series—			
Angling		$1,699,074 35	
Hunting		64 00	
Deer Tags		15 00	
Fish Tags		6,337 75	
Game Tags		165 15	
Market Fisherman		73,000 00	
Fish Importer		80 00	
Fish Party Boat Permit		647 00	
Fish Breeder		535 00	
Game Breeder		2,865 00	
Kelp License		30 00	
Game Management Area License		330 00	
Game Management Area Tags		54	
Salmon Tags		48 00	
Total 1949 Series			$1,783,491 79
1948 Series—			
Angling		1,445,847 55	
Hunting		1,497,107 10	
Archery—Resident		1,956 00	
Archery—Non Resident		25 00	
Commercial Hunting Club		700 00	
Commercial Hunting Club Operator		230 00	
Trapping		1,272 00	
Fish Packers and Shellfish Dealers		16,265 00	
Archery—Deer Tags		734 00	
Deer Tags		300,313 00	
Fish Tags		3,981 24	
Game Tags		438 12	
Market Fisherman		69,080 00	
Fish Importer		10 00	
Fish Party Boat Permits		184 00	
Fish Breeder		60 00	
Game Breeder		375 00	
Game Management Area Licenses		120 00	
Game Management Area Tags		367 83	
Salmon Tags		146 94	
Deer Meat Agents—Locker Permits		10,600 50	
Deer Meat Agents—Wardens		937 00	
Waterfowl Permits		3,198 00	
Total 1948 Series			3,353,948 28
1947 Series:			
Angling	Debit	$59 00	
Hunting		958 50	
Archery—Deer Tags	Debit	10 00	
Total 1947 Series			889 50
Other Revenue—			
Fish Packers Tax		166,737 41	
Sardine Tax		87,991 07	
Kelp Tax Revenue		2,236 50	
Lease on Kelp Beds		998 10	
Salmon Tax		52,084 03	
Confiscated Fish		61,566 86	
Miscellaneous Revenue—Undetermined		24,138 30	
Miscellaneous Revenue		43,111 84	
Court Fines		177,273 30	
Interest on Surplus Money Investment Fund		23,198 64	
Total Other Revenue			638,806 33
Total Revenue			5,777,135 90
Less License Commissions Deducted By Agents			248,618 97
Net Revenue			5,528,516 93
Revenue for the Wildlife Restoration Fund From Pari-Mutuels			$3,000,000 00

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